Using Earth Observations and Ecosystem Modeling to Improve the Sustainability of Agribusiness & Extractive Industries in Working Landscapes (the Gobi, Mongolia)

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Natural Capital Project, Stanford University

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@natcapproject

natural capital PROJECT


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Толгой
KERING
WCS
Woods Institute
for the Environment
Stanford University
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PROJECT
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Wild Mongolia


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Sustainable Cashmere Project

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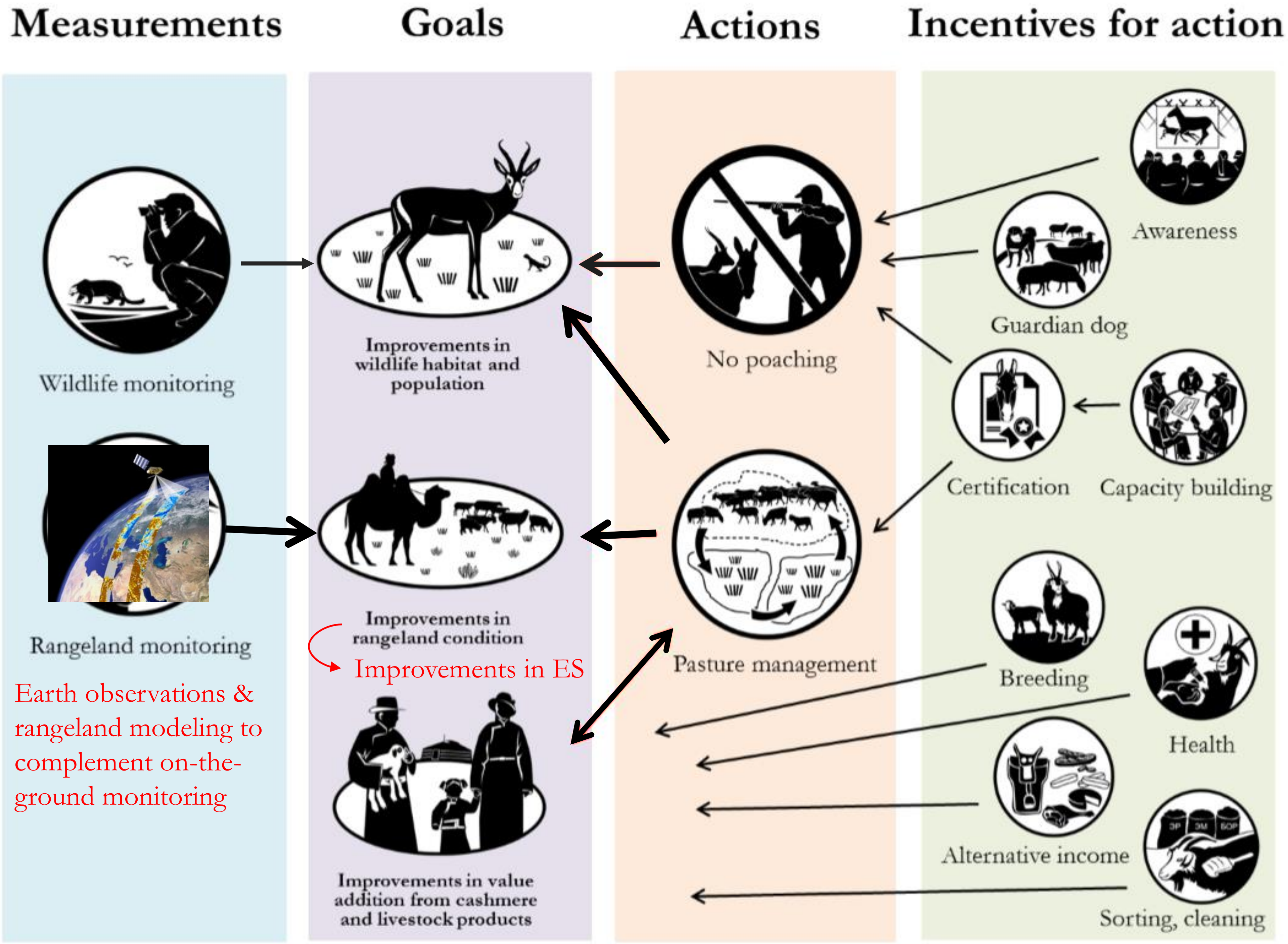
NASA



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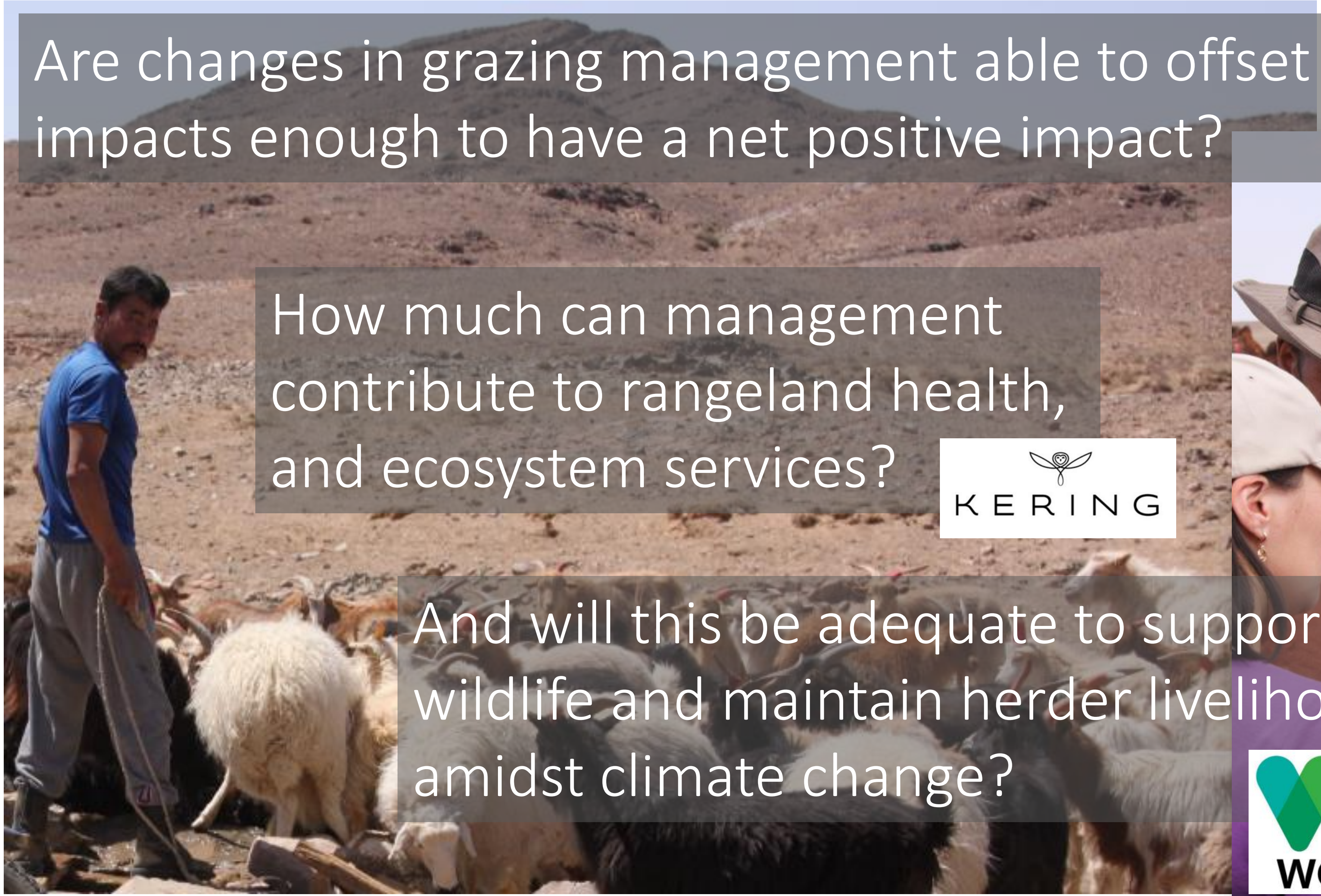

Are changes in grazing management able to offset mining impacts enough to have a net positive impact?

How much can management contribute to rangeland health, and ecosystem services?

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And will this be adequate to support wildlife and maintain herder livelihoods, amidst climate change?

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How can we scale up our understanding of management impacts?

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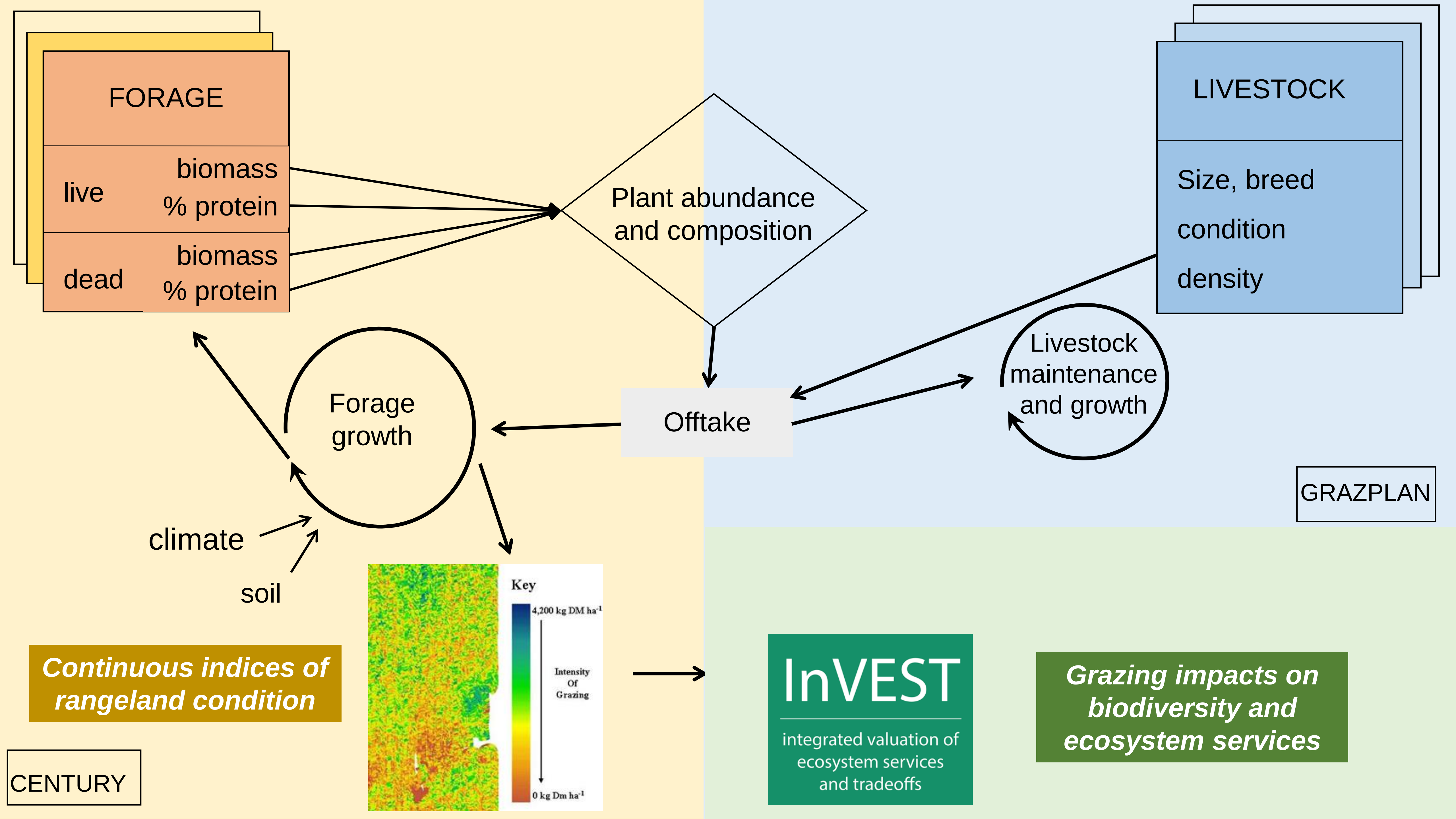
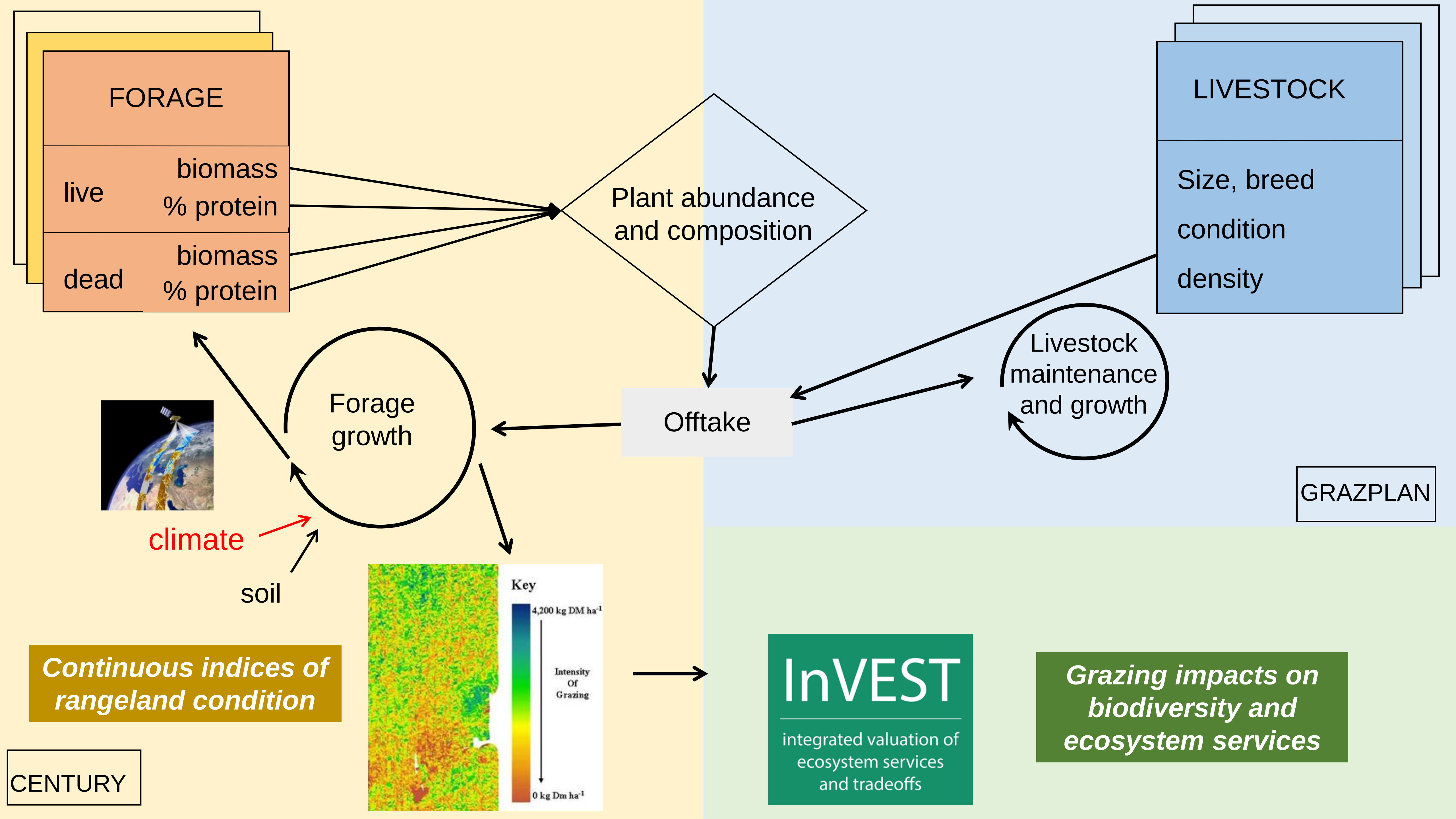

FORAGE
live
biomass
% protein
dead
biomass
% protein
Plant abundance and composition
LIVESTOCK
Size, breed
condition
density
Offtake
Forage growth
Livestock maintenance and growth
climate
soil
GRAZPLAN
Key
4,200 kg DM ha-1
Intensity Of Grazing
0 kg Dm ha-1
Continuous indices of rangeland condition
CENTURY
InVEST
integrated valuation of ecosystem services and tradeoffs
Grazing impacts on biodiversity and ecosystem services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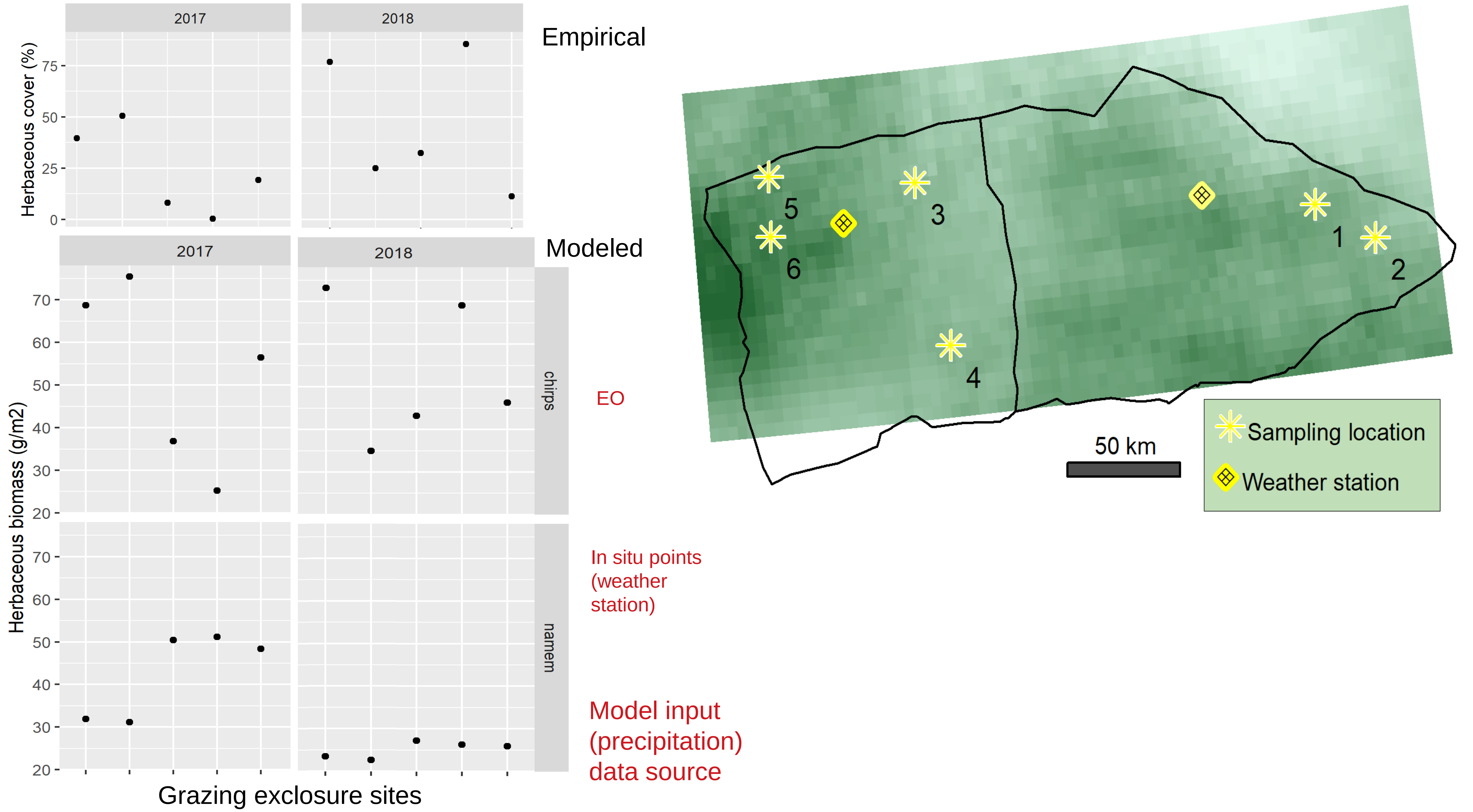
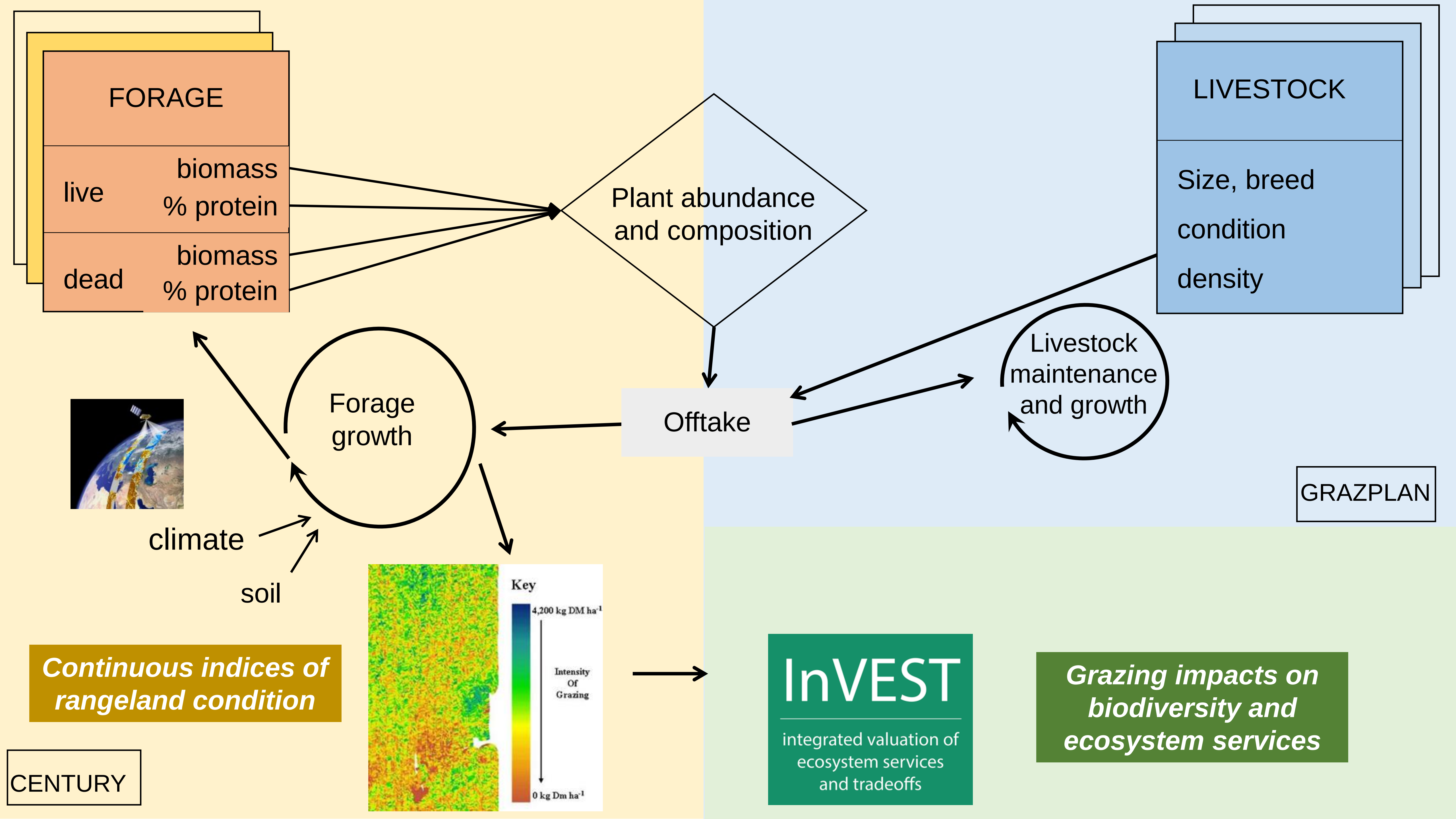


2017
2018
Empirical
Herbaceous cover (%)
75
50
25
0
2017
2018
Modeled
70
60
50
40
30
20
Herbaceous biomass (g/m2)
chirps
EO
namem
In situ points (weather station)
Model input (precipitation) data source
Grazing exclosure sites
1
2
3
4
5
6
50 km
Sampling location
Weather station



FORAGE
live
biomass
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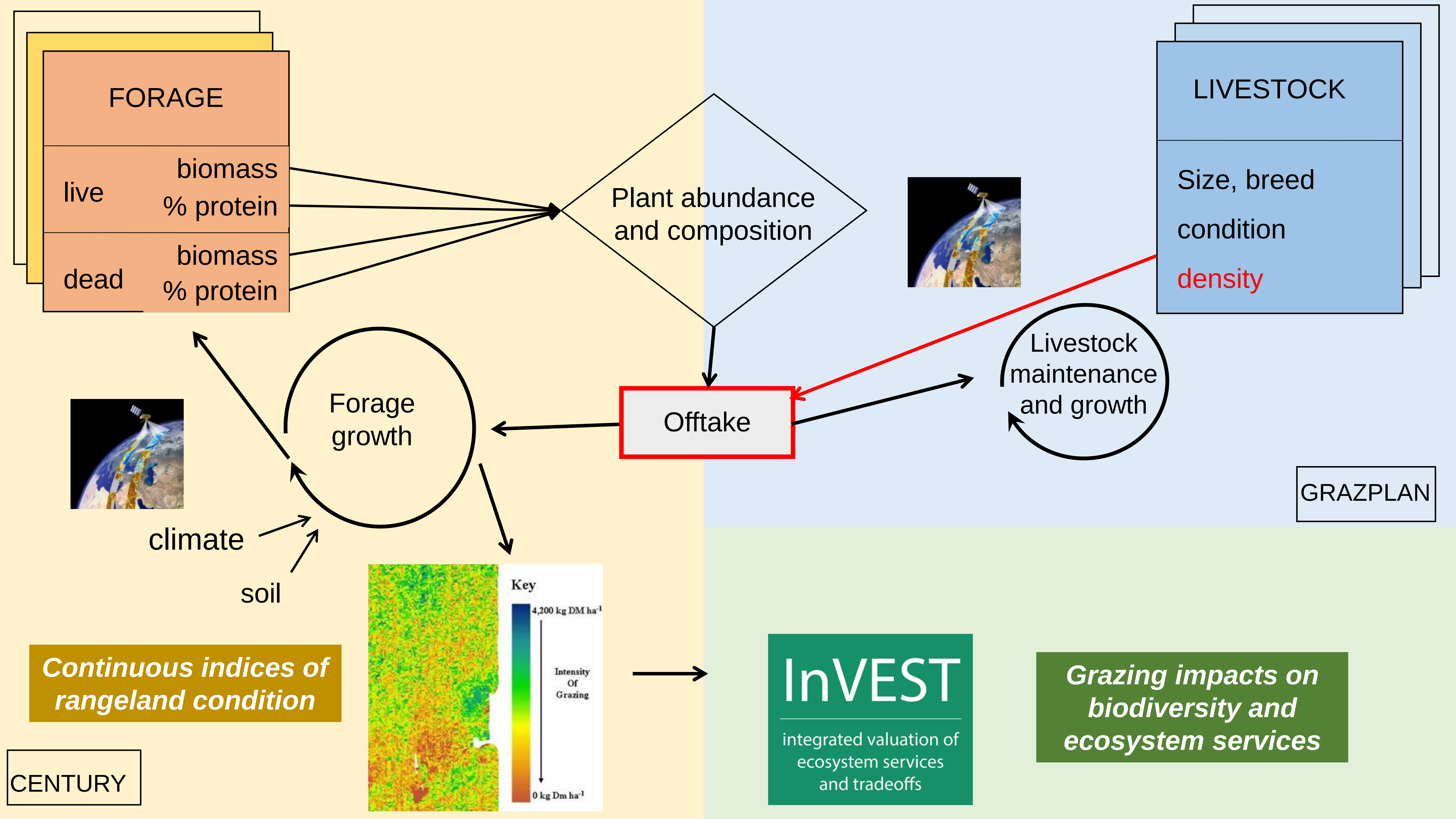

FORAGE
live
biomass
% protein
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Plant abundance and composition
LIVESTOCK
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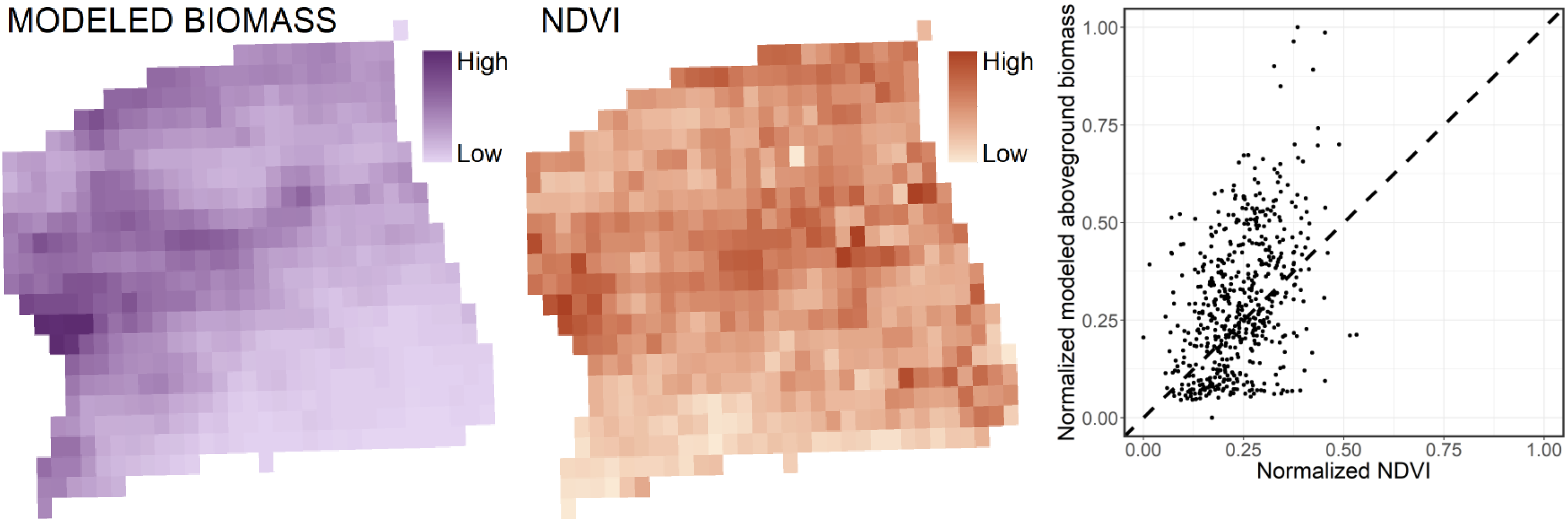
Grazing impacts on biodiversity and ecosystem services

Grazing model “calibration” approach

Inferring grazing intensity from rangeland model mismatch with vegetation index



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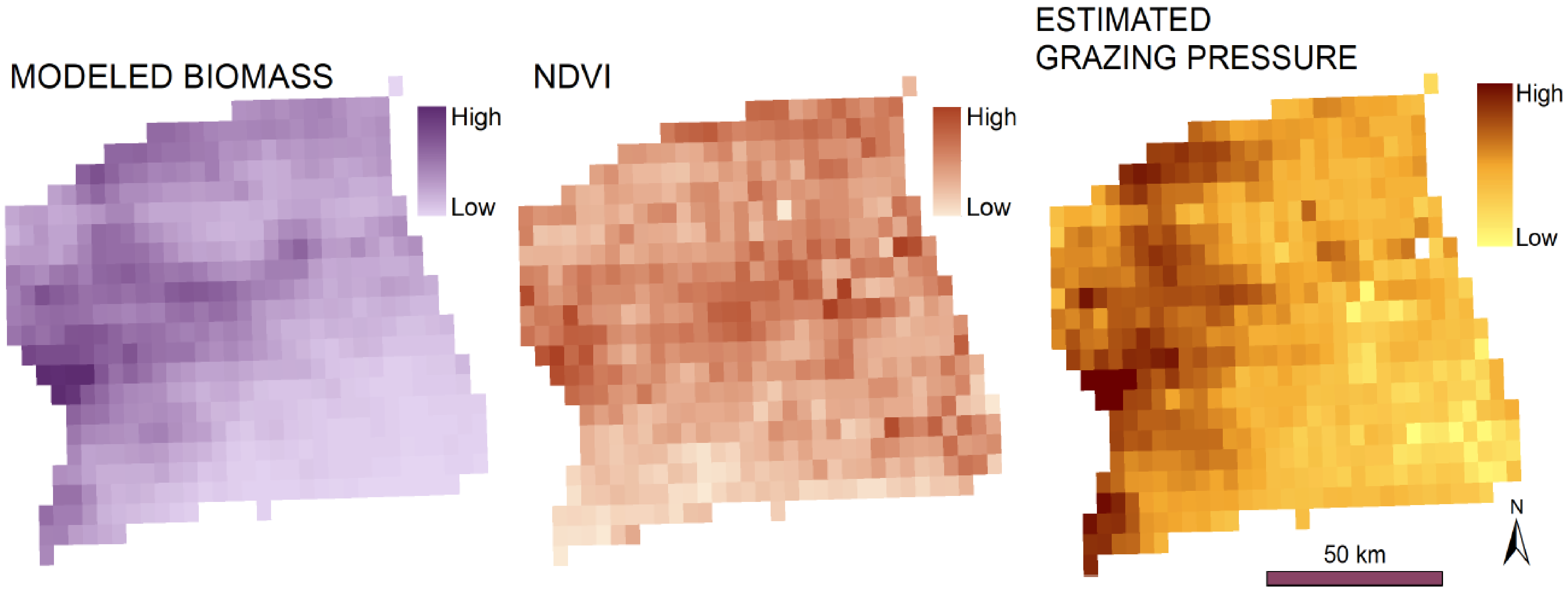
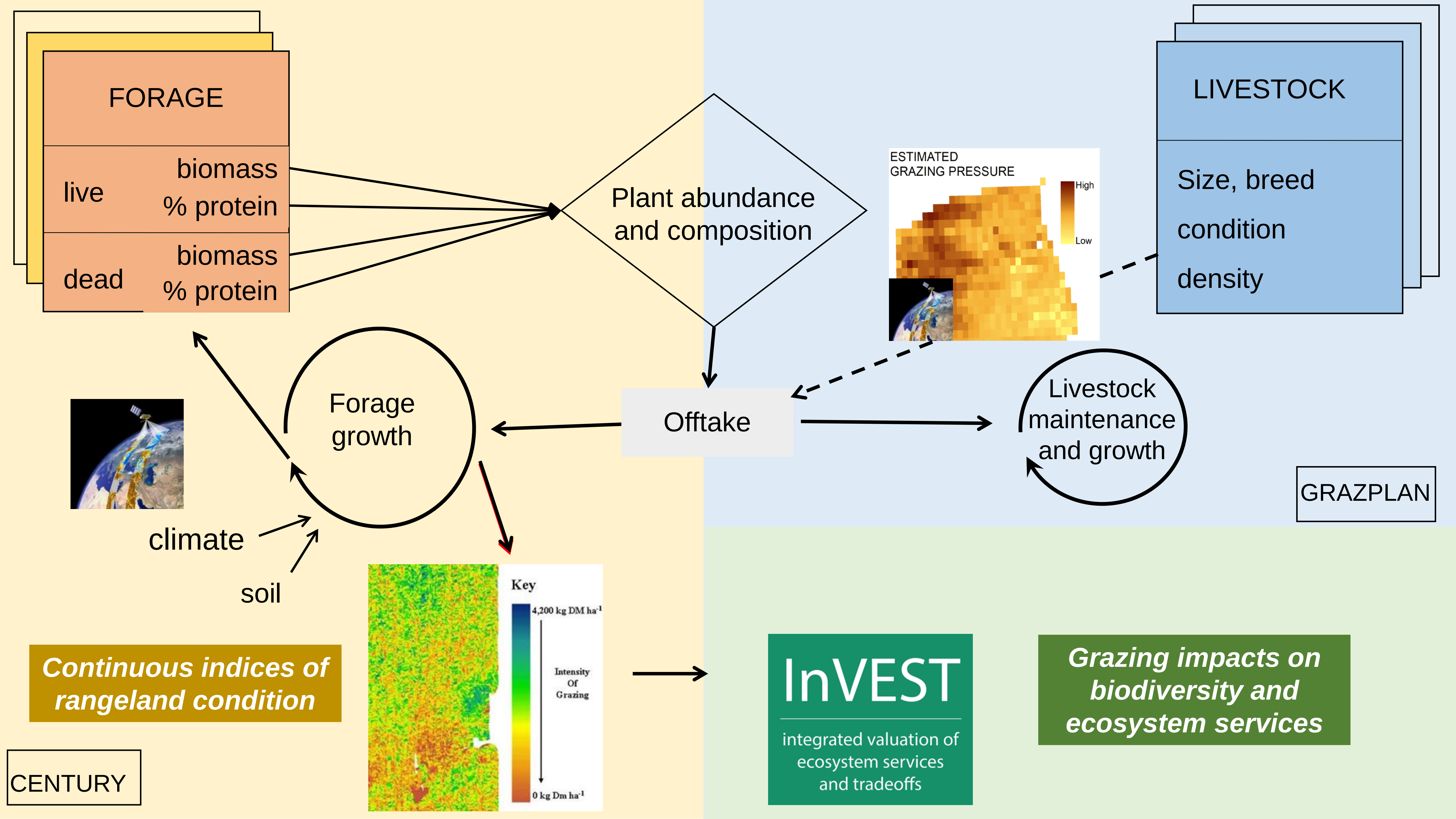
Inferring grazing intensity from rangeland model mismatch with vegetation index




FORAGE
live
biomass
% protein
dead
biomass
% protein
Plant abundance and composition
ESTIMATED GRAZING PRESSURE
High
Low
LIVESTOCK
Size, breed
condition
density
Forage growth
Offtake
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Are changes in grazing management able to offset mining impacts enough to have a net positive impact?

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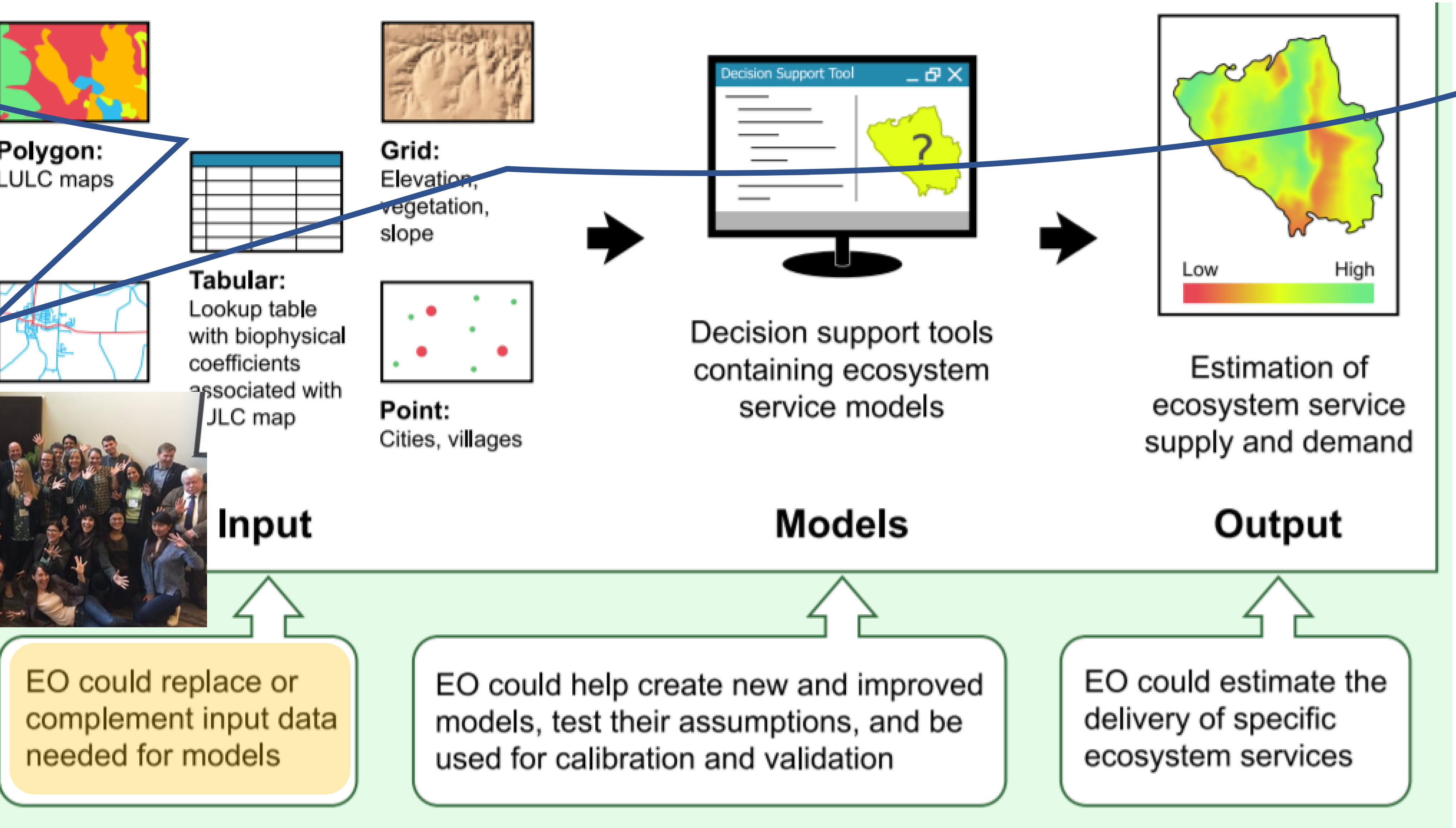
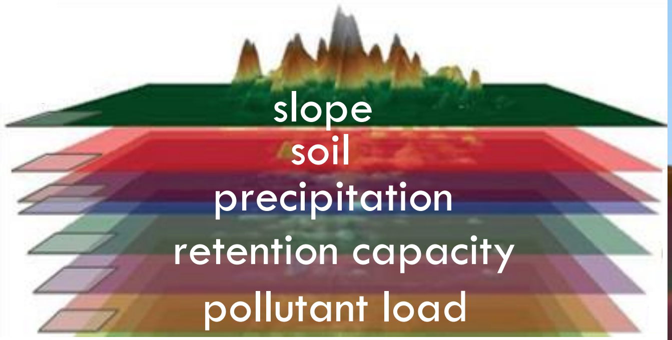
How can earth observations contribute to ecosystem services modeling?

How can Earth observations improve ecosystem services modeling?

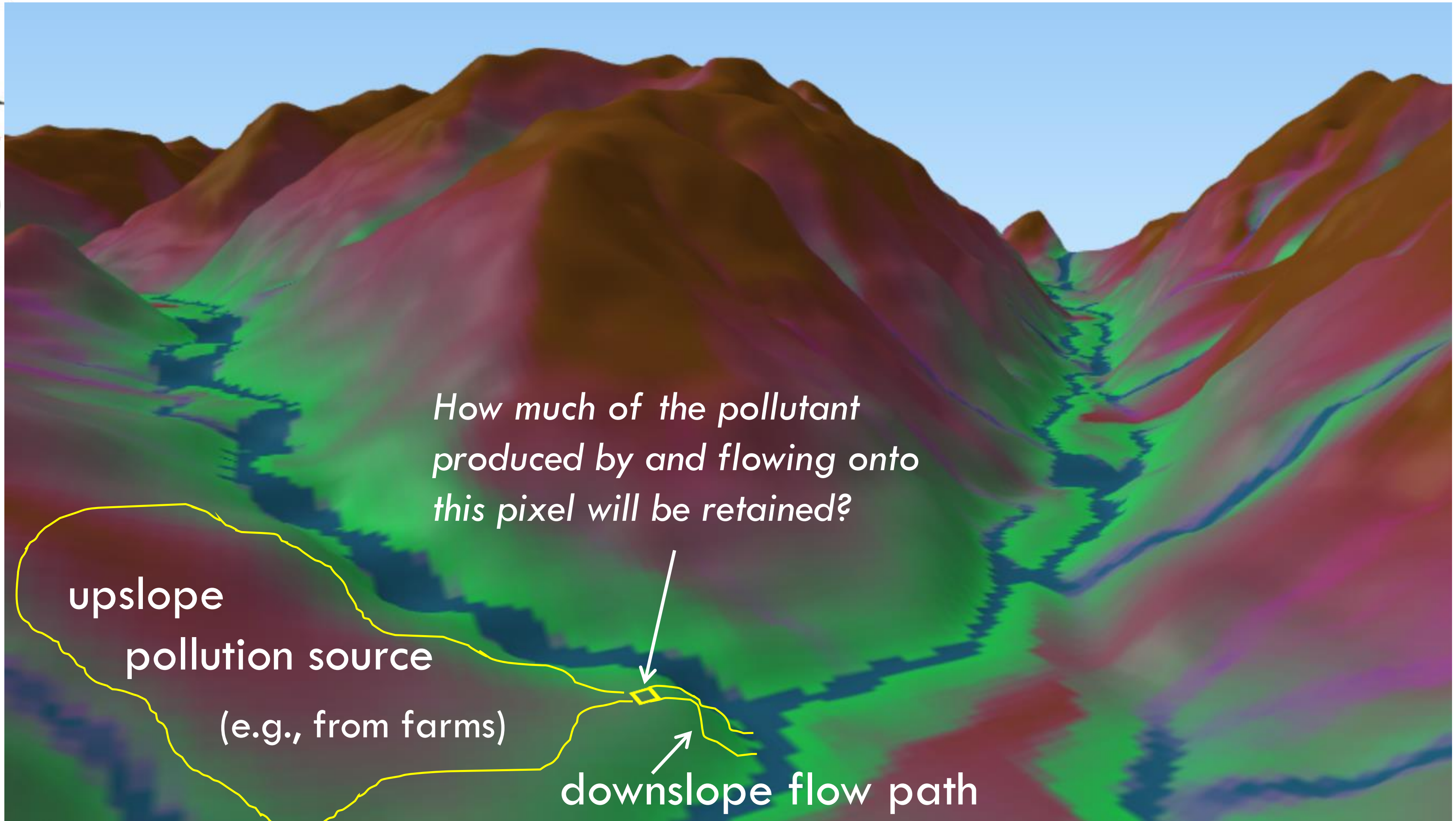


Ramirez-Reyes et al. 2019

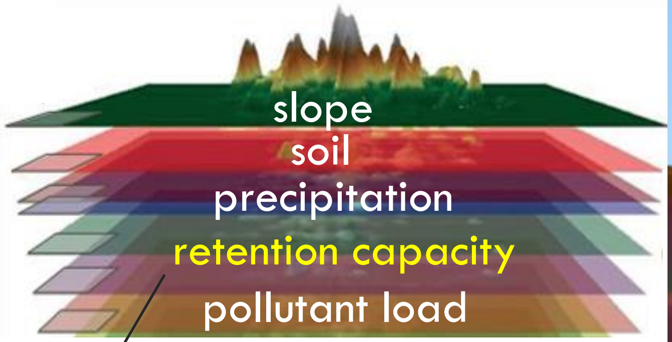
How can Earth observations improve ecosystem services modeling?



Water quality regulation

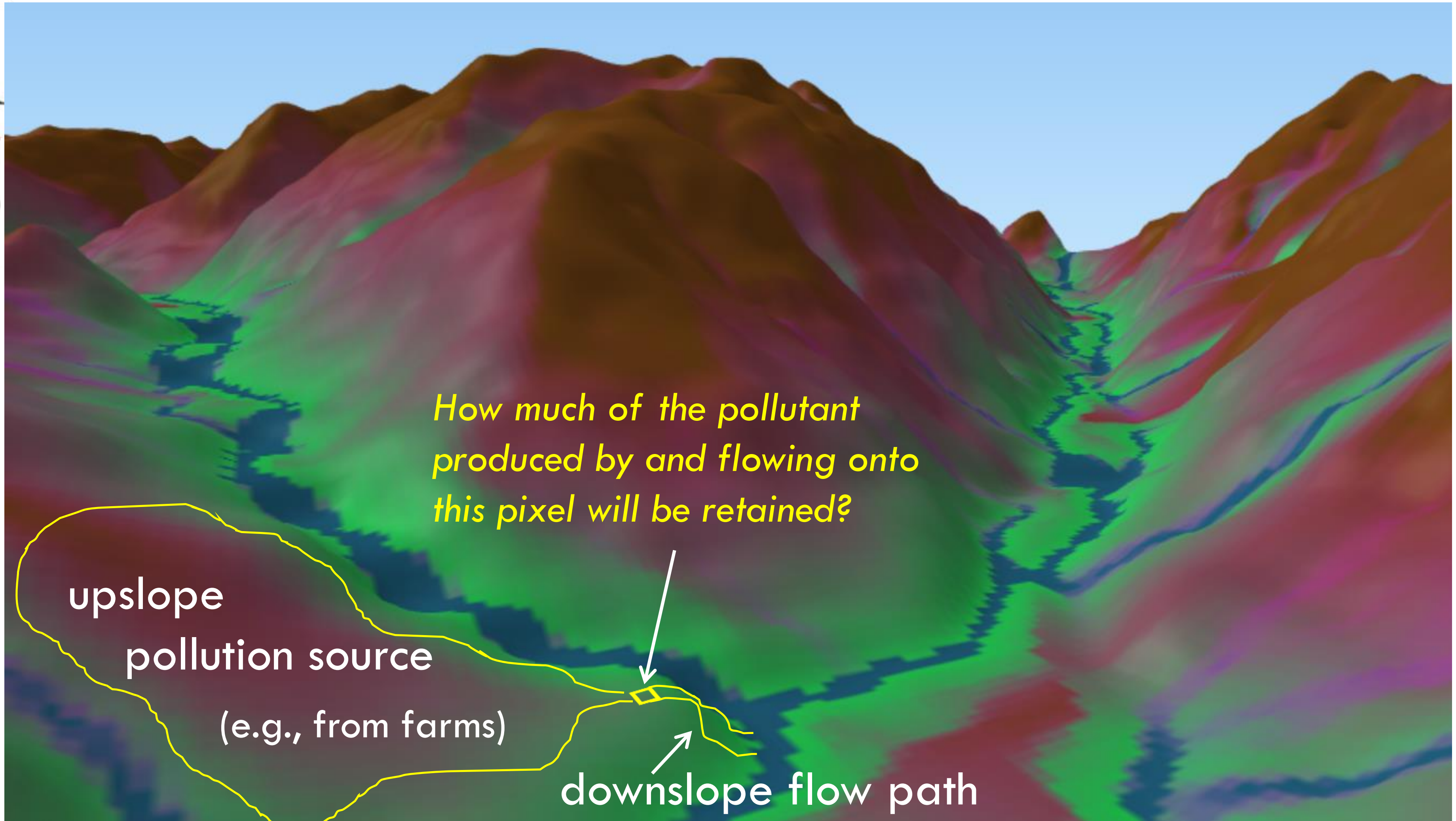


How can Earth observations improve ecosystem services modeling?



Defined by LULC

description	lucode	usle_c	usle_p
Urban and paved roads	1	0.99	1
Grass	3	0.034	1
General agriculture	5	0.412	1
Tea	6	0.08135	1
Coffee	7	0.4393	1
Forest	8	0.025	1
Water	9	0	1
Forest plantation	11	0.121	1
Unpaved road	18	1	1
Agroforestry	19	0.121	1



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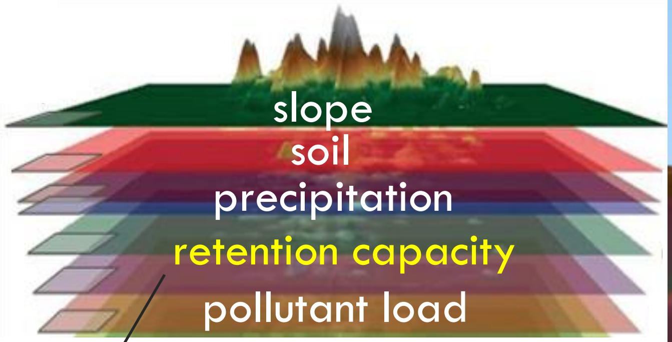
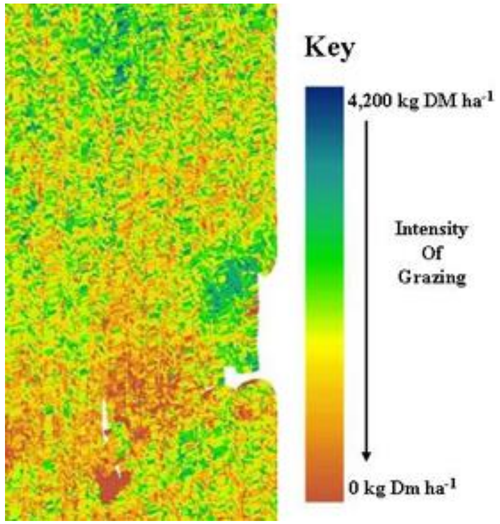
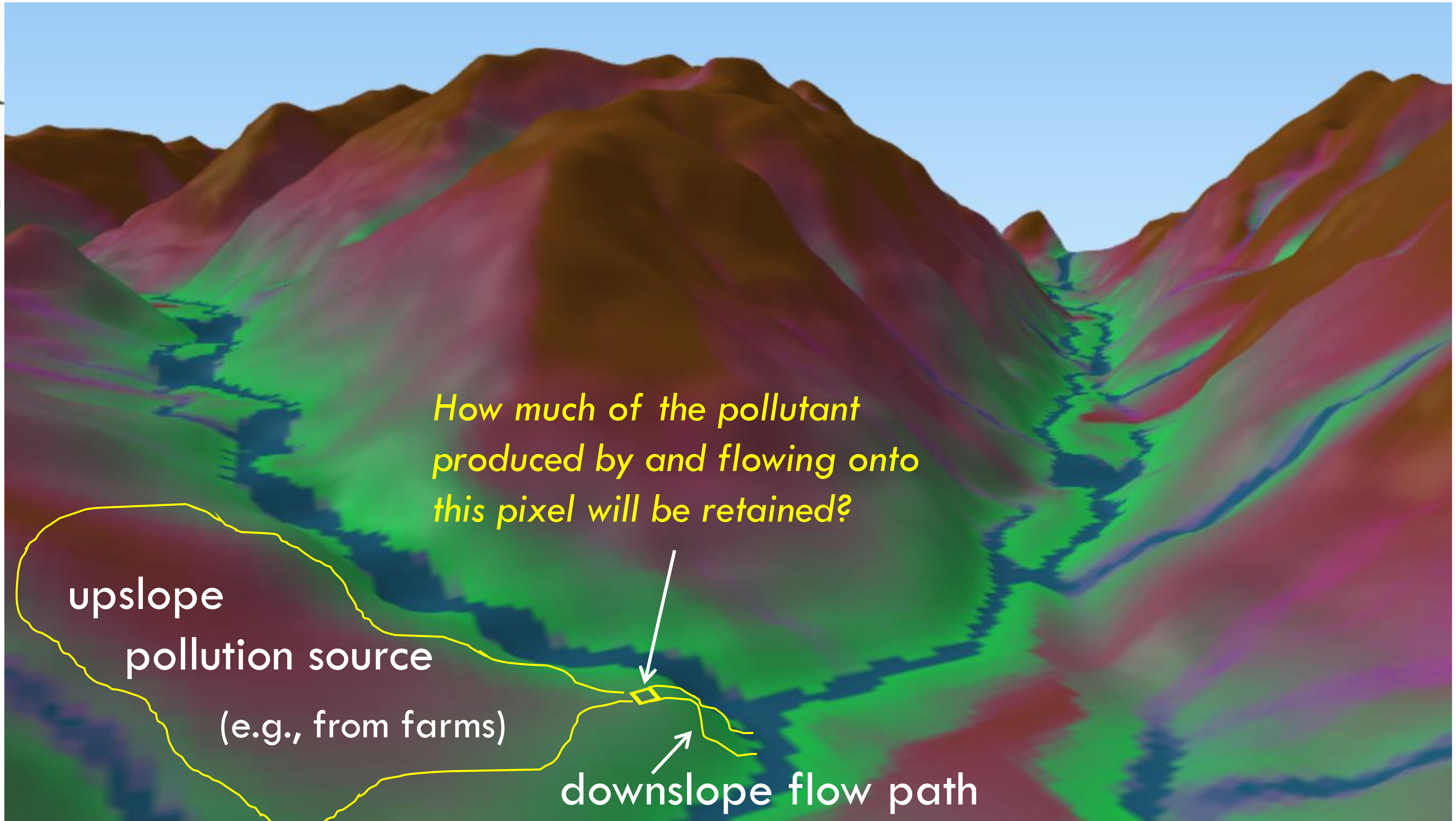
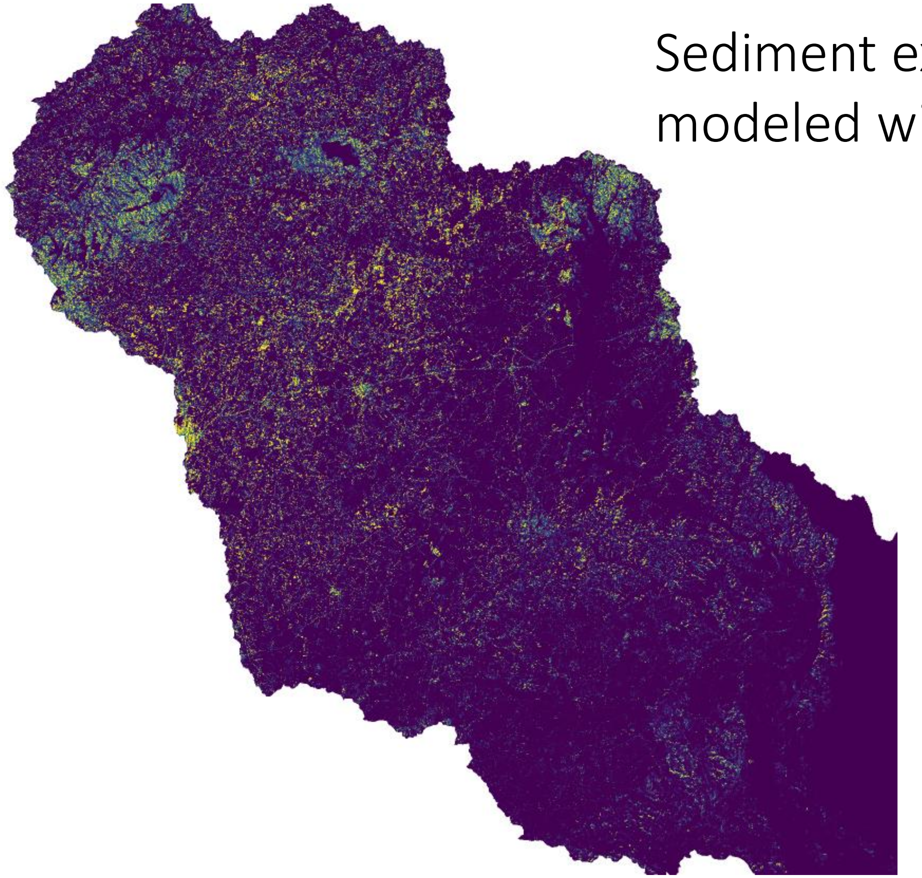


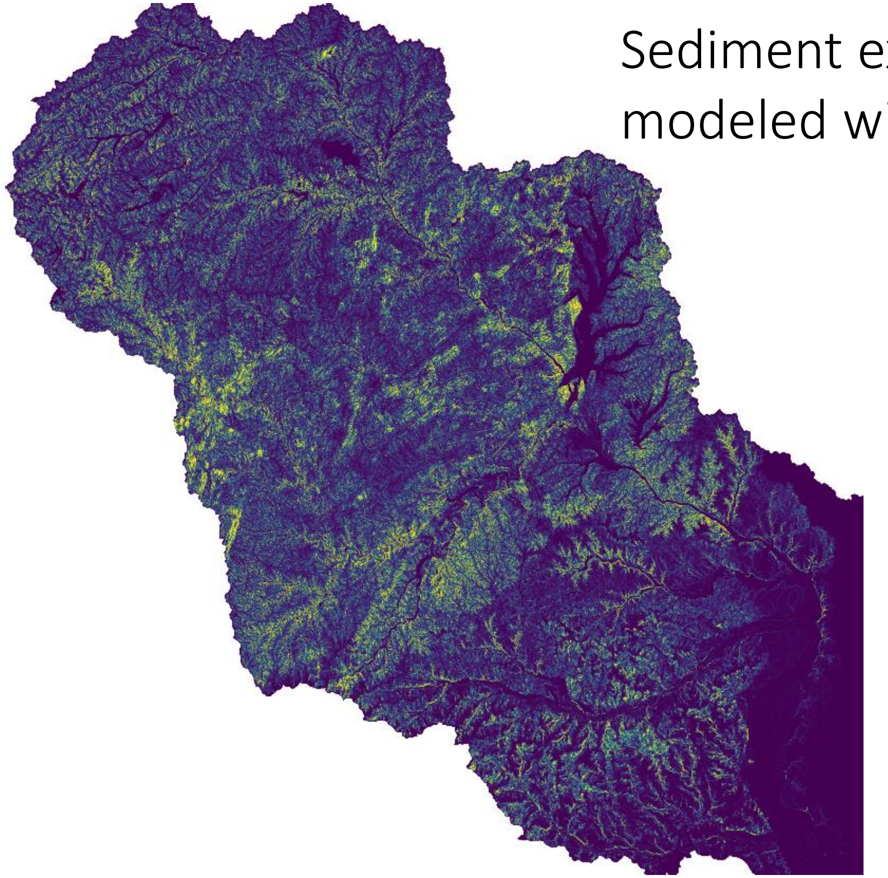
Defined by ~~LULC~~ ecosystem condition



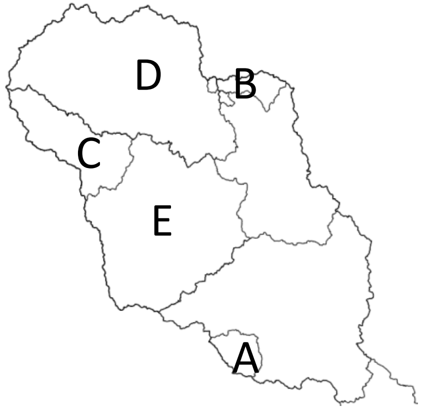


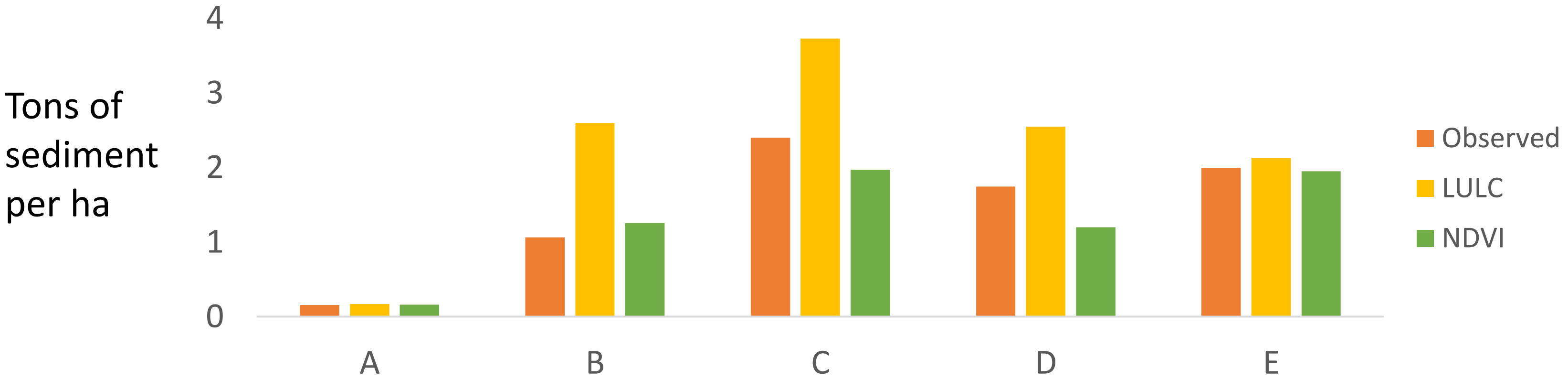


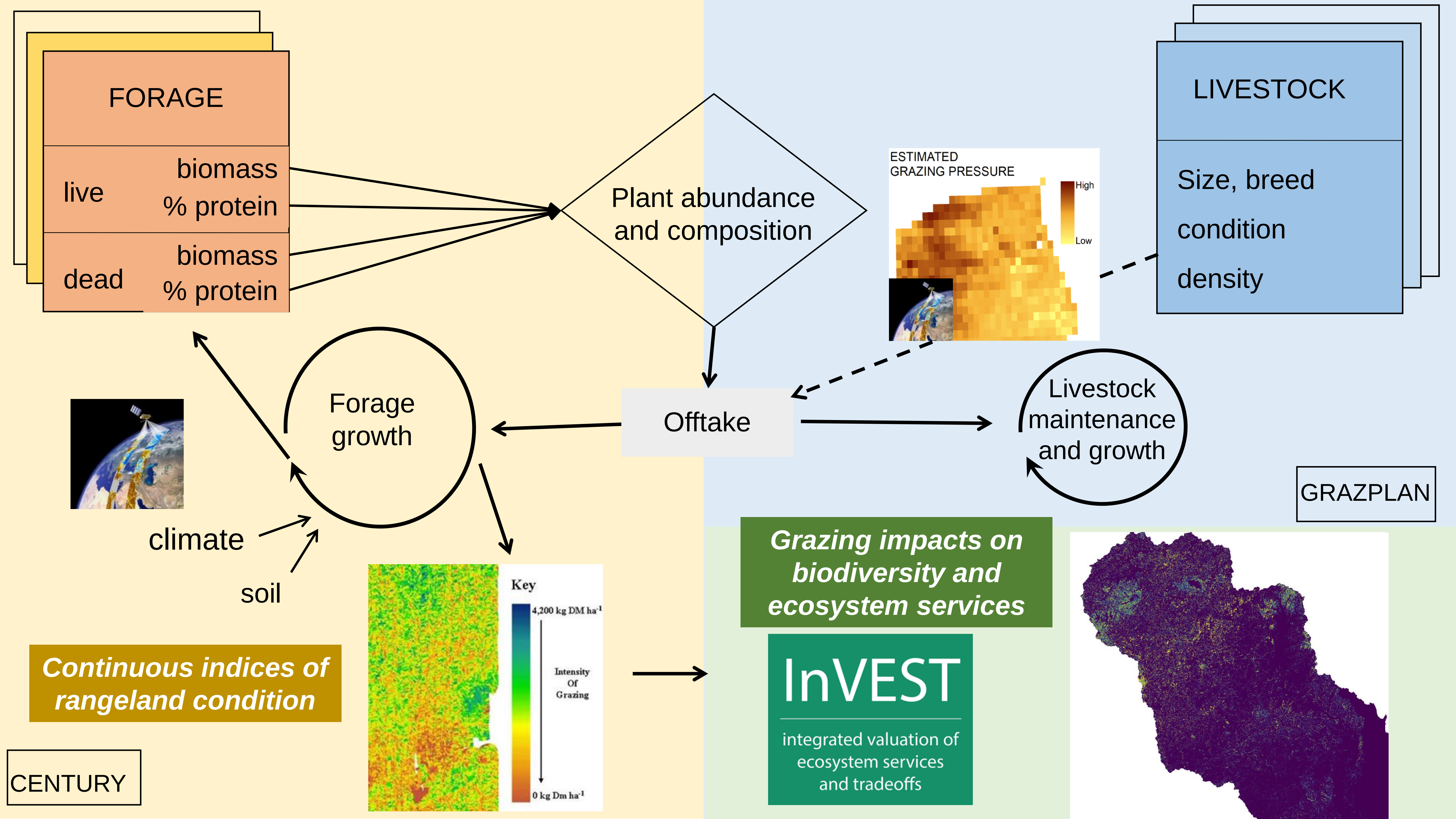
Sediment export modeled with LULC



Sediment export modeled with NDVI






FORAGE
live
biomass
% protein
dead
biomass
% protein
Plant abundance and composition
ESTIMATED GRAZING PRESSURE
High
Low
LIVESTOCK
Size, breed
condition
density
Forage growth
Offtake
Livestock maintenance and growth
climate
soil
Key
4,200 kg DM ha-1
Intensity Of Grazing
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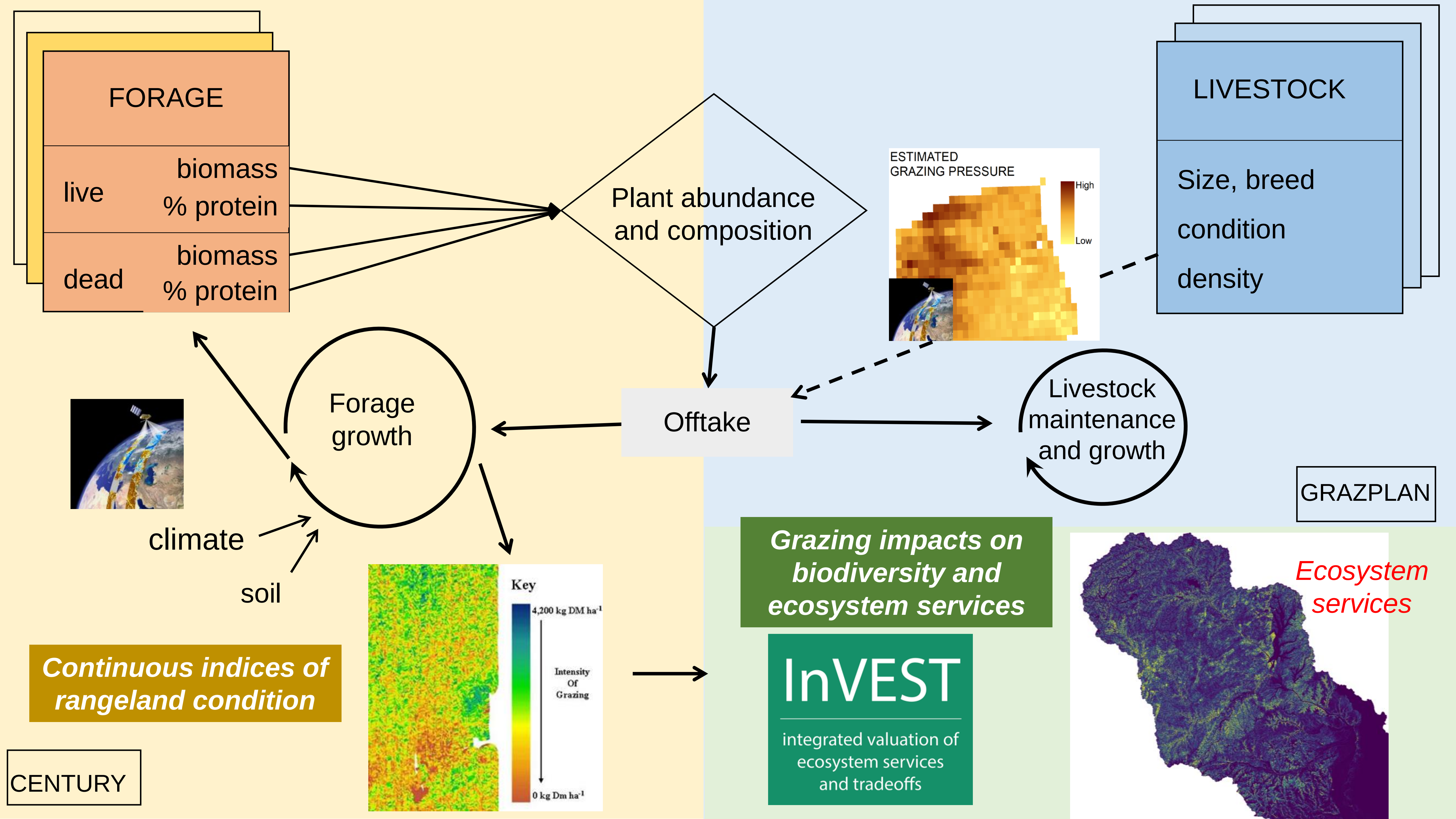
GRAZPLAN
Grazing impacts on biodiversity and ecosystem services
InVEST
integrated valuation of ecosystem services and tradeoffs
Continuous indices of rangeland condition
CENTURY



FORAGE
live
biomass
% protein
dead
biomass
% protein
Plant abundance and composition
ESTIMATED GRAZING PRESSURE
High
Low
LIVESTOCK
Size, breed
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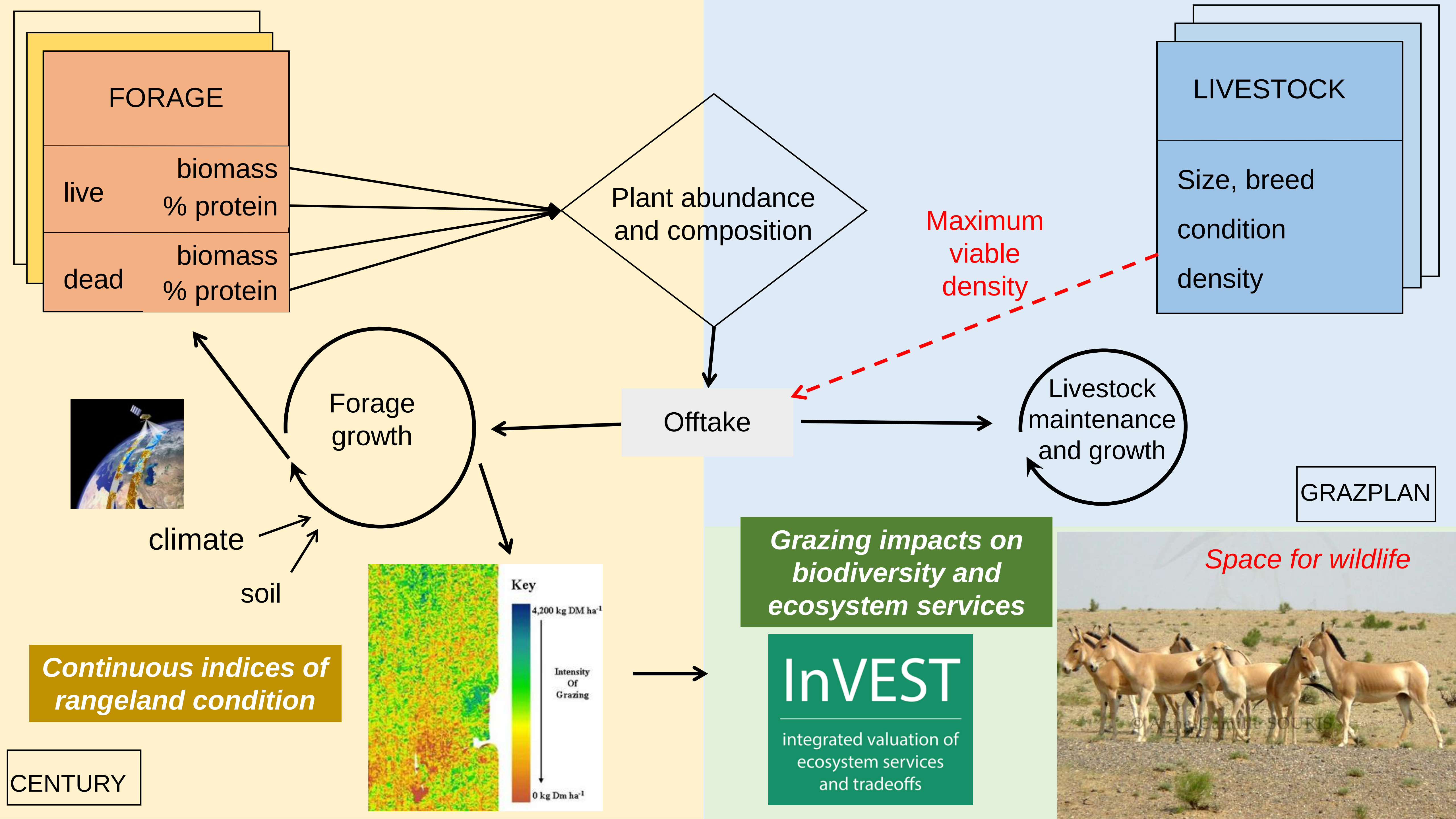
How much does management vs. climate affect “space” for wildlife?

And will this be adequate to support wildlife and maintain herder livelihoods, amidst climate change?



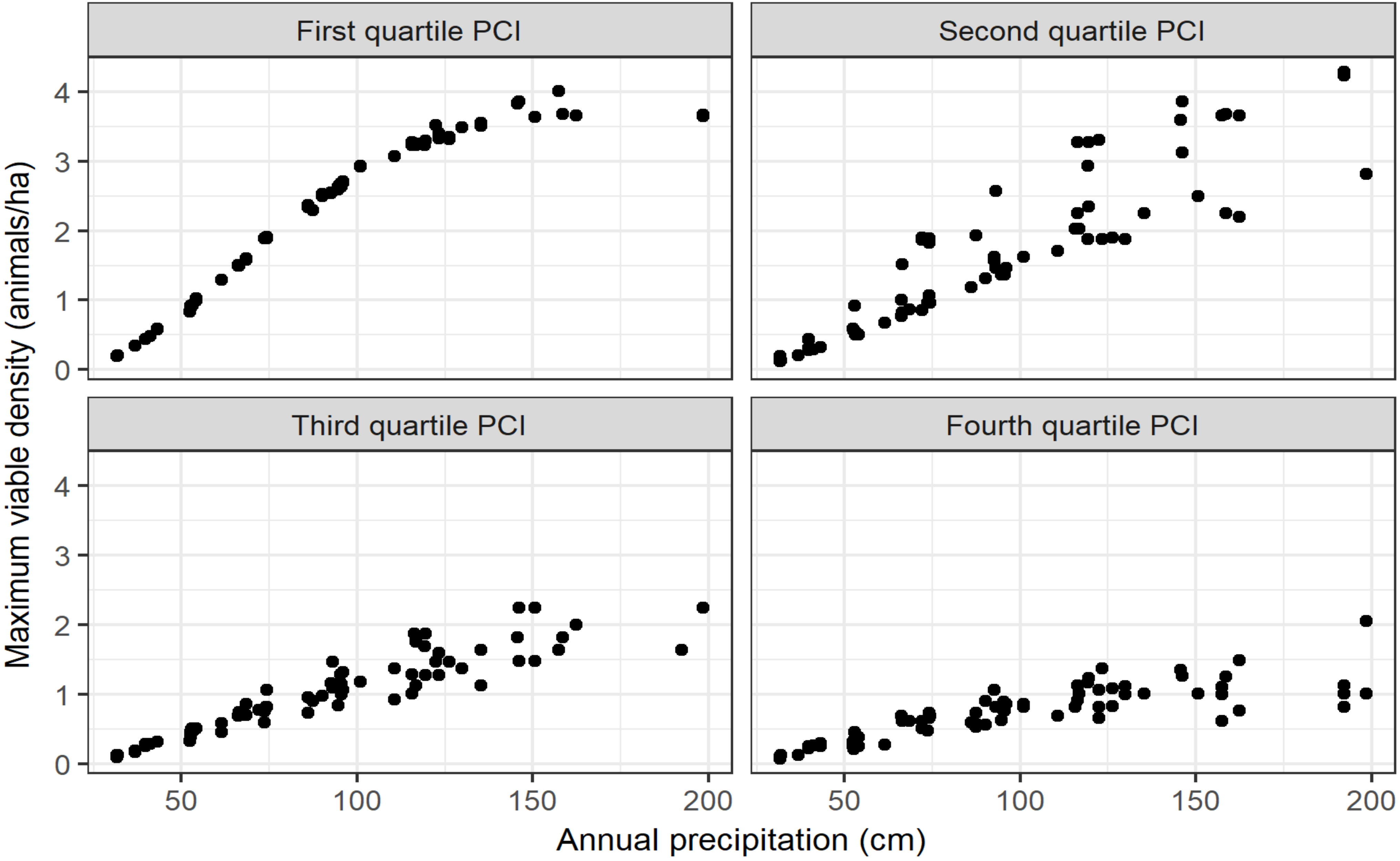
FORAGE
live
biomass
% protein
dead
biomass
% protein
Plant abundance and composition
LIVESTOCK
Size, breed
condition
density
Maximum viable density
Forage growth
Offtake
Livestock maintenance and growth
climate
soil
GRAZPLAN
Key
4,200 kg DM ha-1
Intensity Of Grazing
0 kg Dm ha-1
Grazing impacts on biodiversity and ecosystem services
Space for wildlife
InVEST
integrated valuation of ecosystem services and tradeoffs
Continuous indices of rangeland condition
CENTURY

Impact of precipitation amount vs. variability

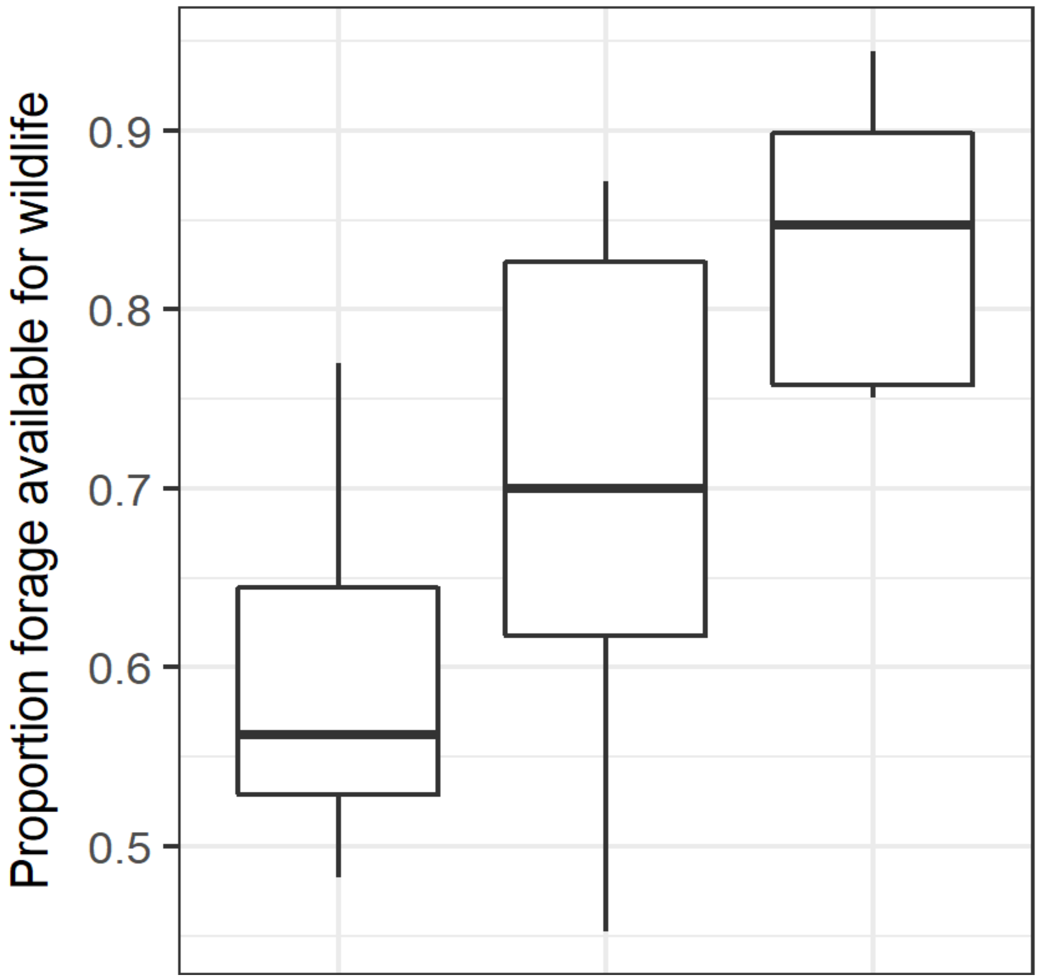
Precipitation Concentration Index (PCI)

First quartile = most uniform

Fourth quartile = most irregular



Climate and management impacts on wildlife potential

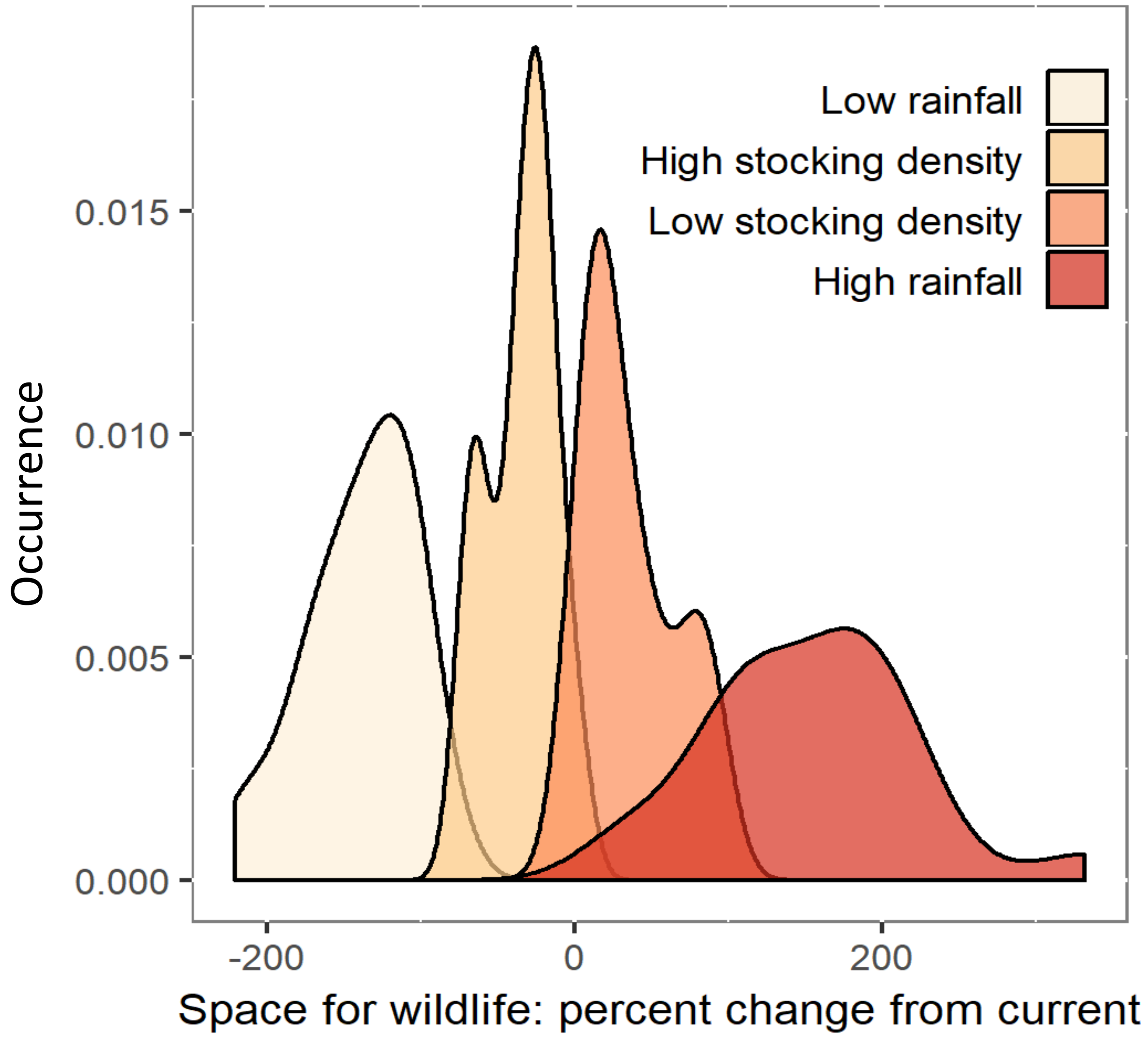


Across a range of climate conditions

Highest livestock density

Medium livestock density

Lowest livestock density



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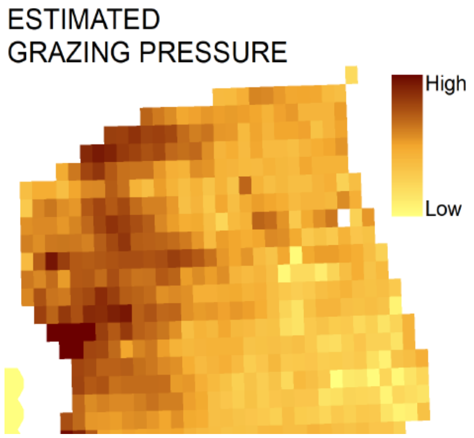
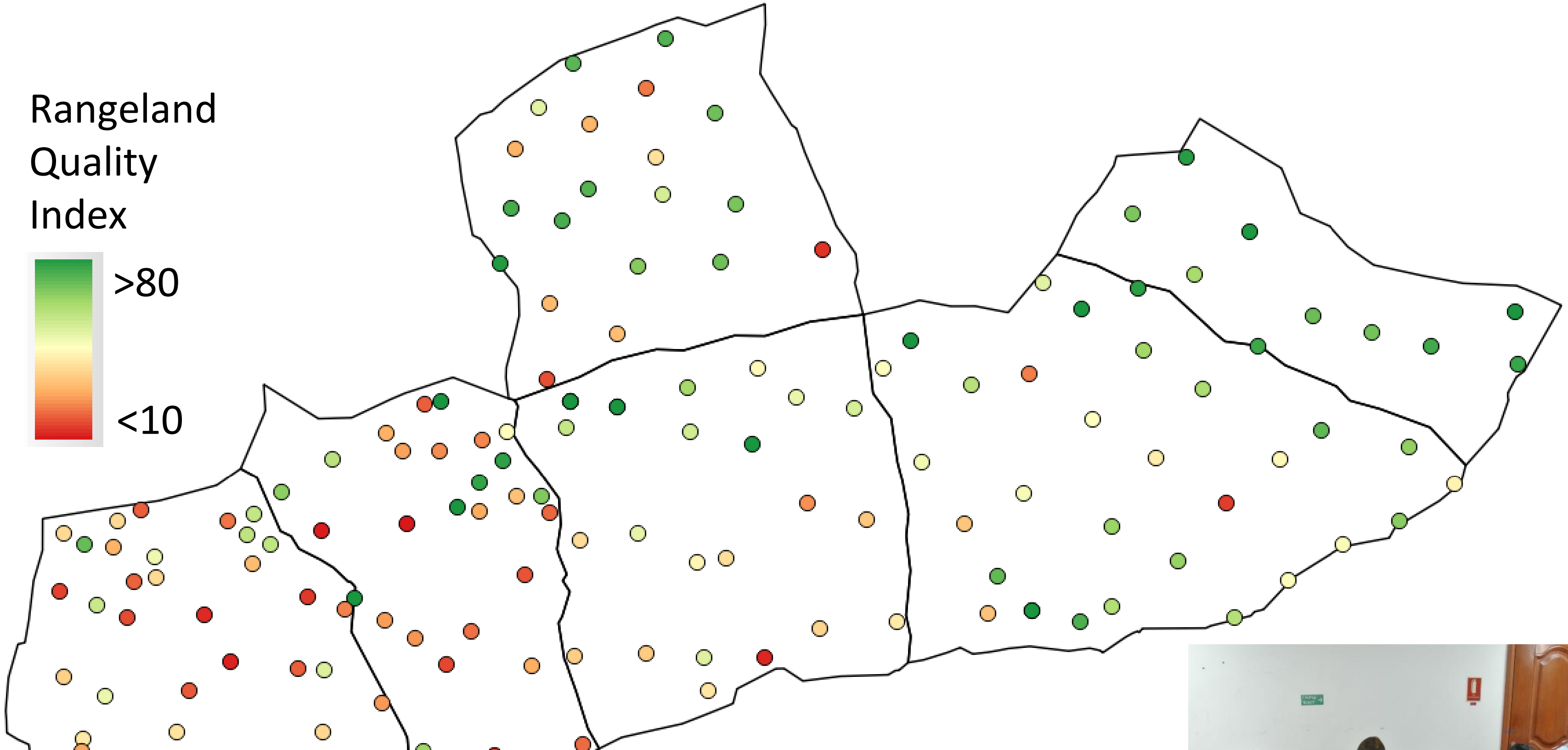
Are changes in grazing management able to offset mining impacts enough to have a net positive impact?

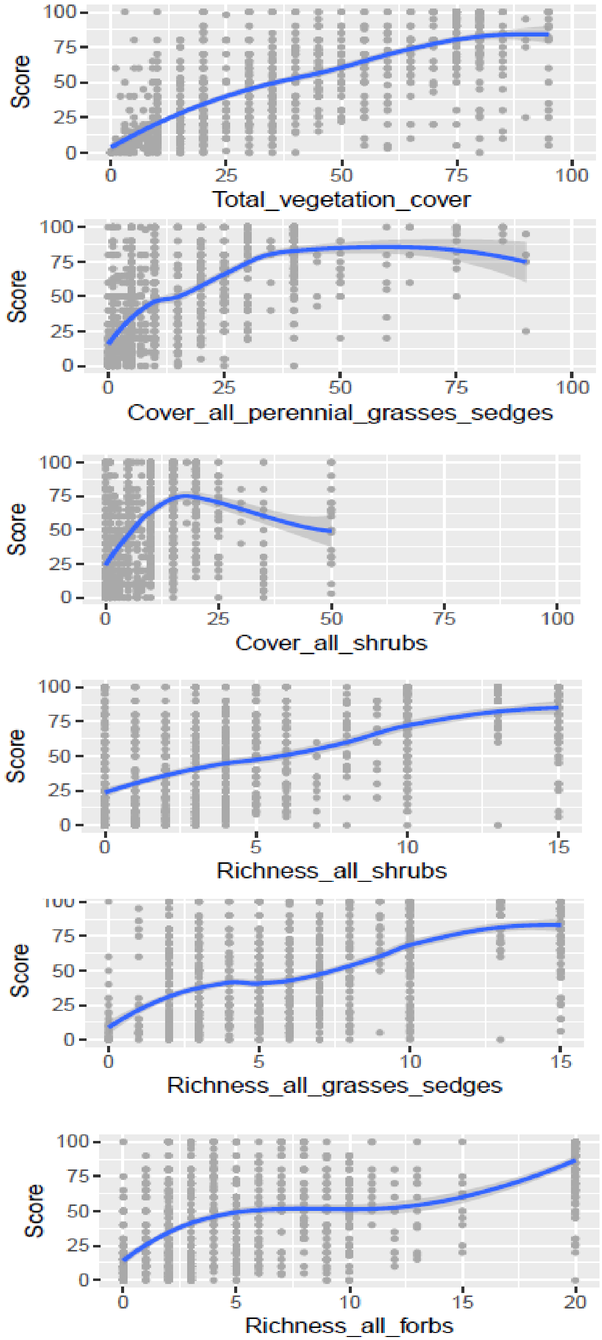
How can we detect changes in management?



How can we detect changes in rangeland quality?

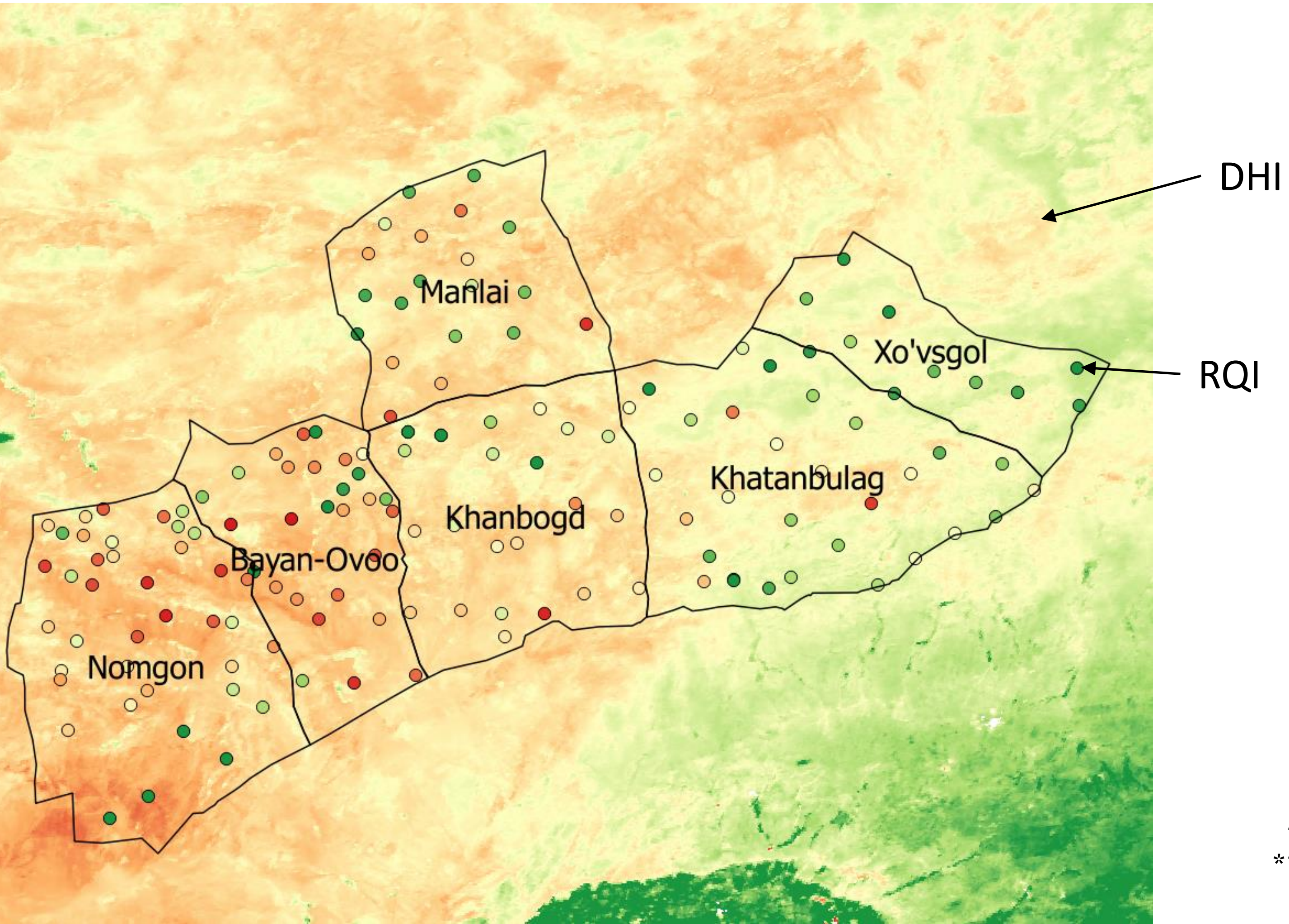
“Rangeland quality”
Complex index, characterized by experts

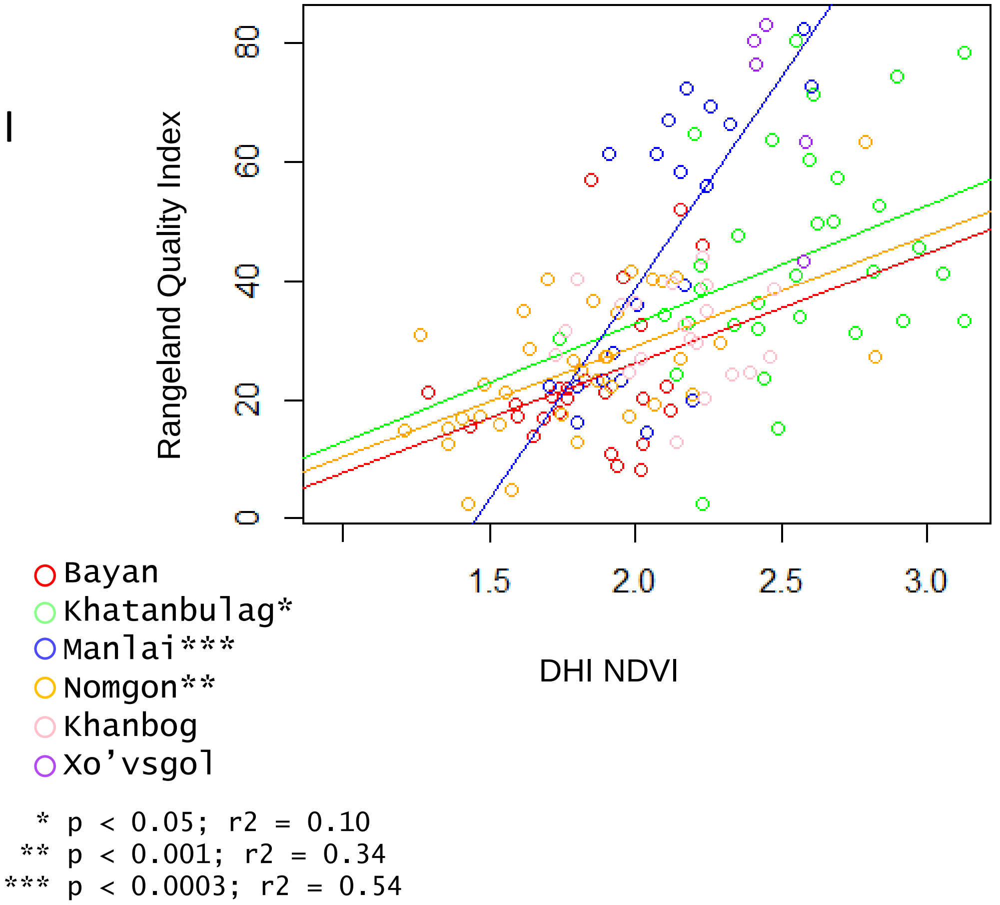




Long-term vegetation patterns: Dynamic Habitat Index

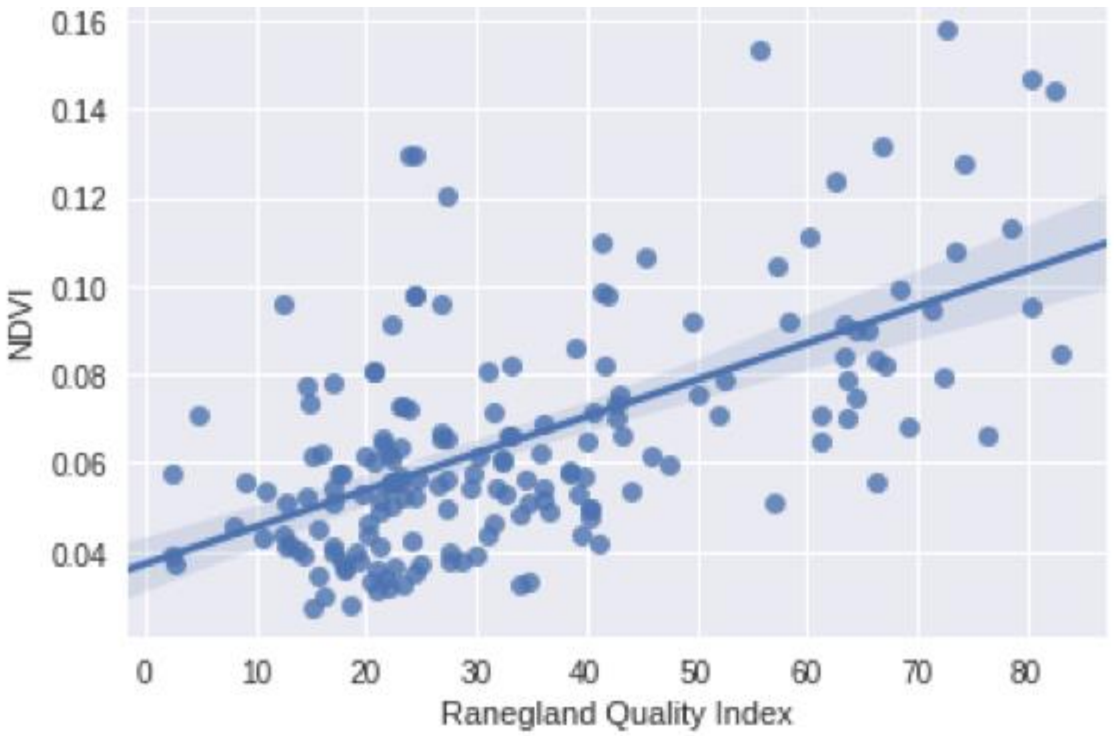
DHI from MODIS NDVI - captures long term variability in vegetation greenness over time – better metric of resilience characteristics related to rangeland quality index?

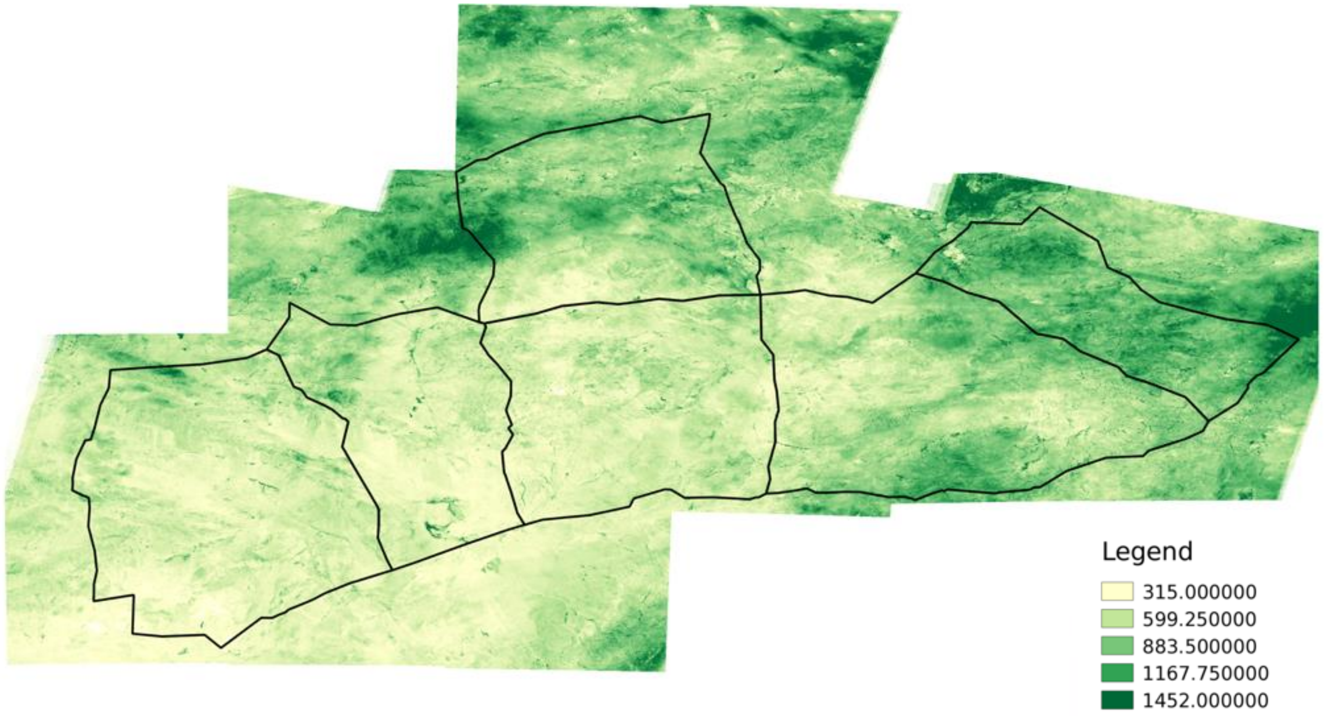




Short-term vegetation patterns: NDVI vs. Rangeland Metric

NDVI taken from Landsat during same windows as on-the-ground sampling





$R2 = 0.36$
$P < 0.001$

Also tried EVI, SAVI, SATVI: mean, max, variance…

Plans for this year:

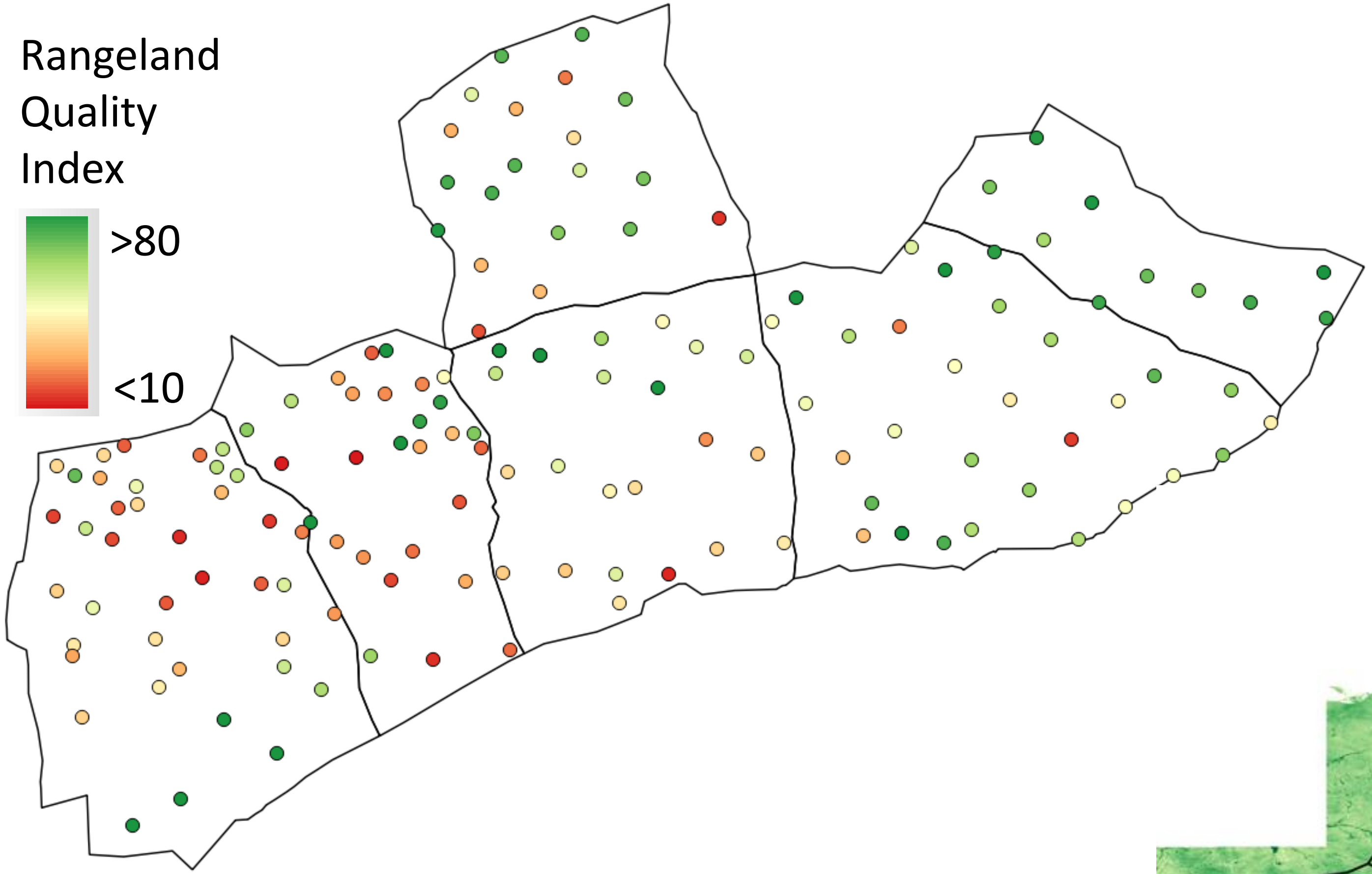
- Test grazing intensity index against empirical grazing data
- Automate linkage between grazing & plant growth models
- Develop linkages between rangeland production & other ES (wind erosion, water regulation)
- Identify best EO products for predicting rangeland quality

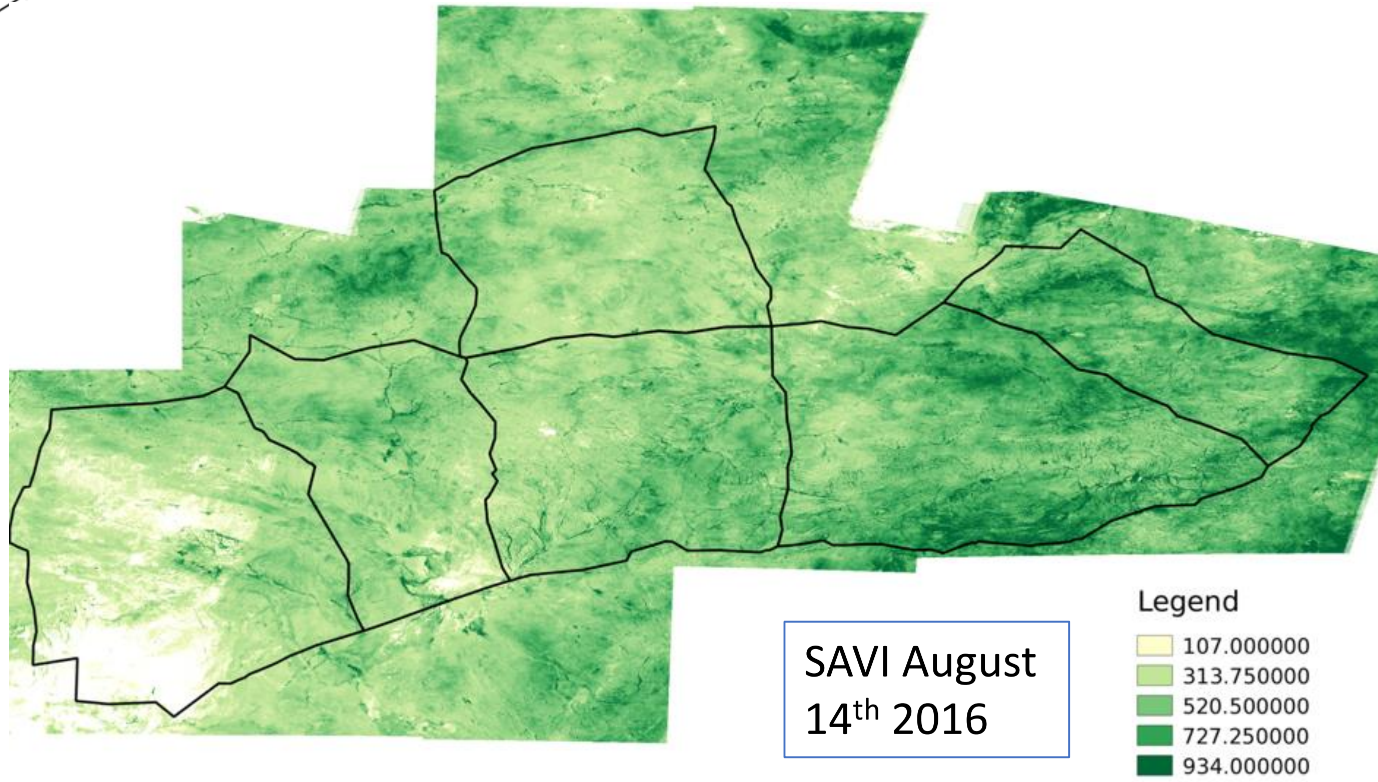
Thank you!

Ginger Kowal
Lingling Liu
Rich Sharp
Onon Bayasgalan
Otgonsuren Avirmed
Enkhtuvshin
Shiilegdamba
Kirk Olson
Samdanjigmed
Tulganyam
Dave Hamilton
Stuart Antsee
Helen Crowley
Cindy Schmidt

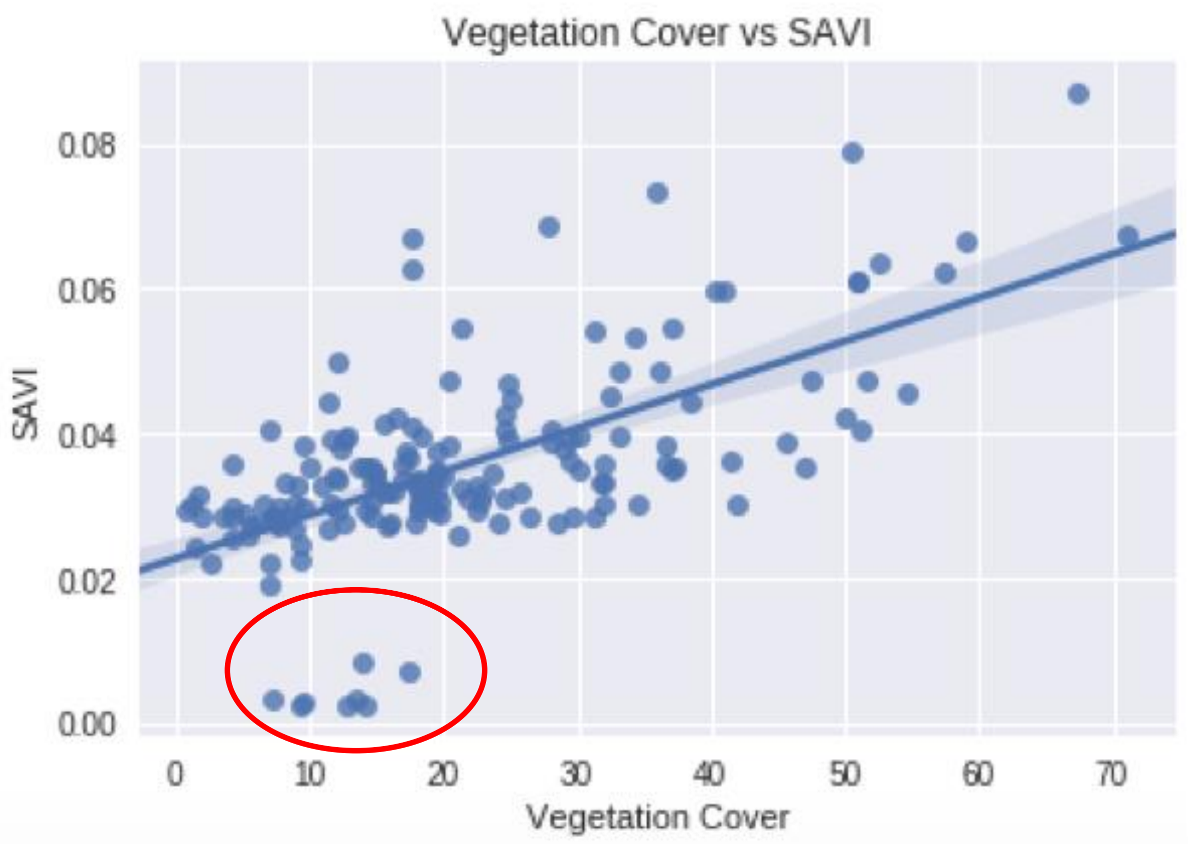
youtu.be/3cvzcR6t2tk

bchaplin@stanford.edu
@beckyck
@natcapproject

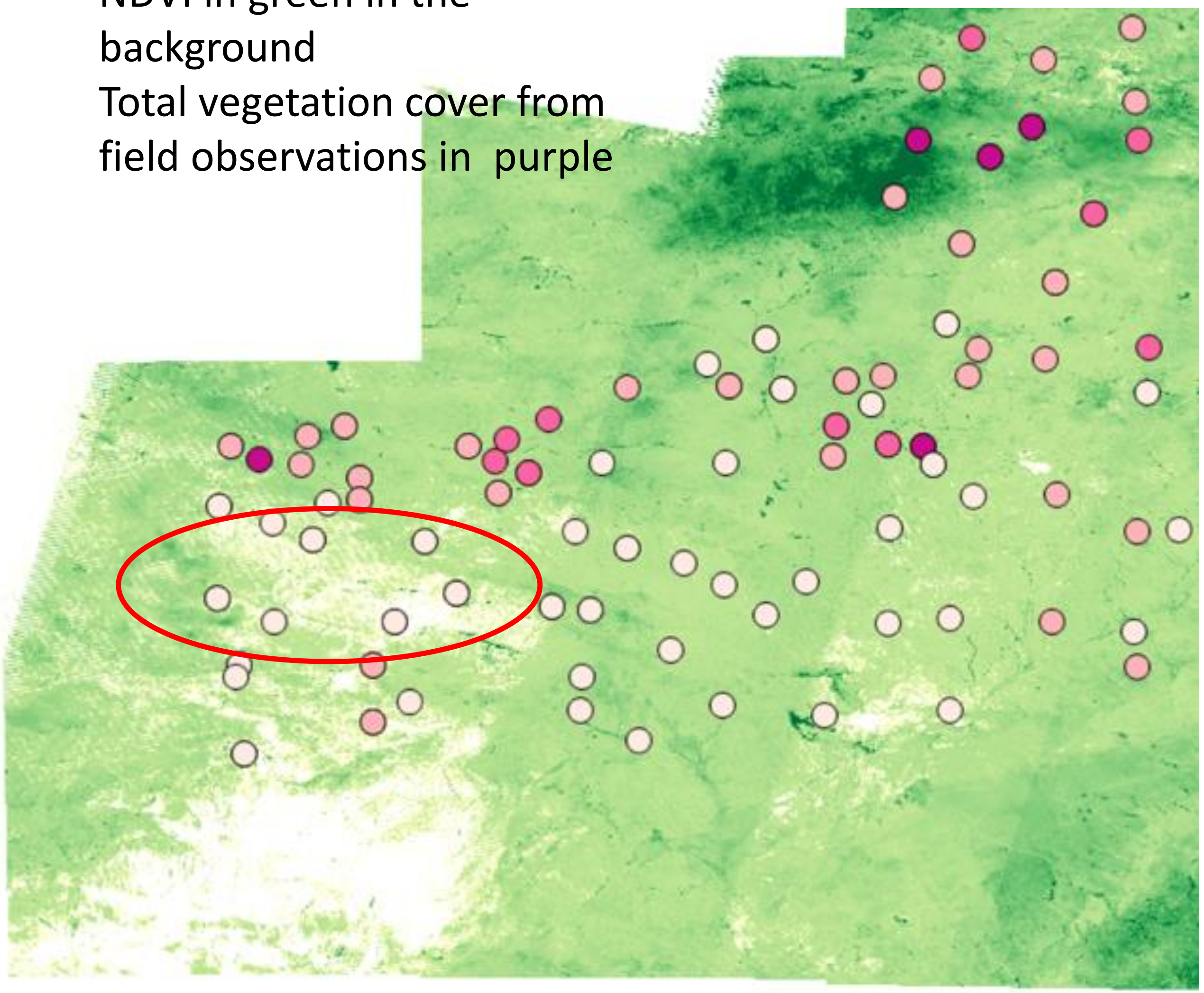

Rangeland
Quality
Index
>80
<10


Legend
107.000000
313.750000
520.500000
727.250000
934.000000
SAVI August
14th 2016

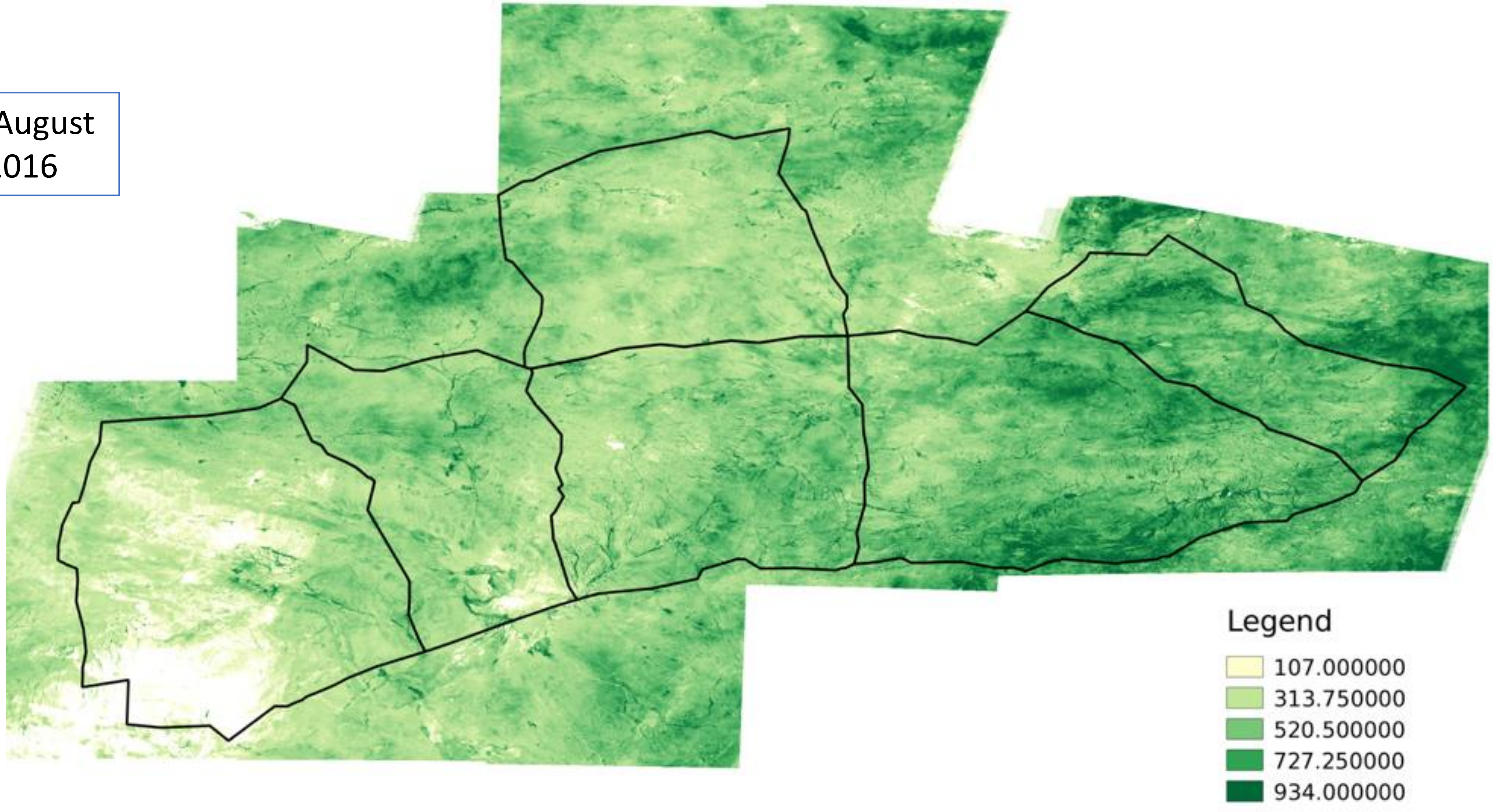
Closer look at outliers



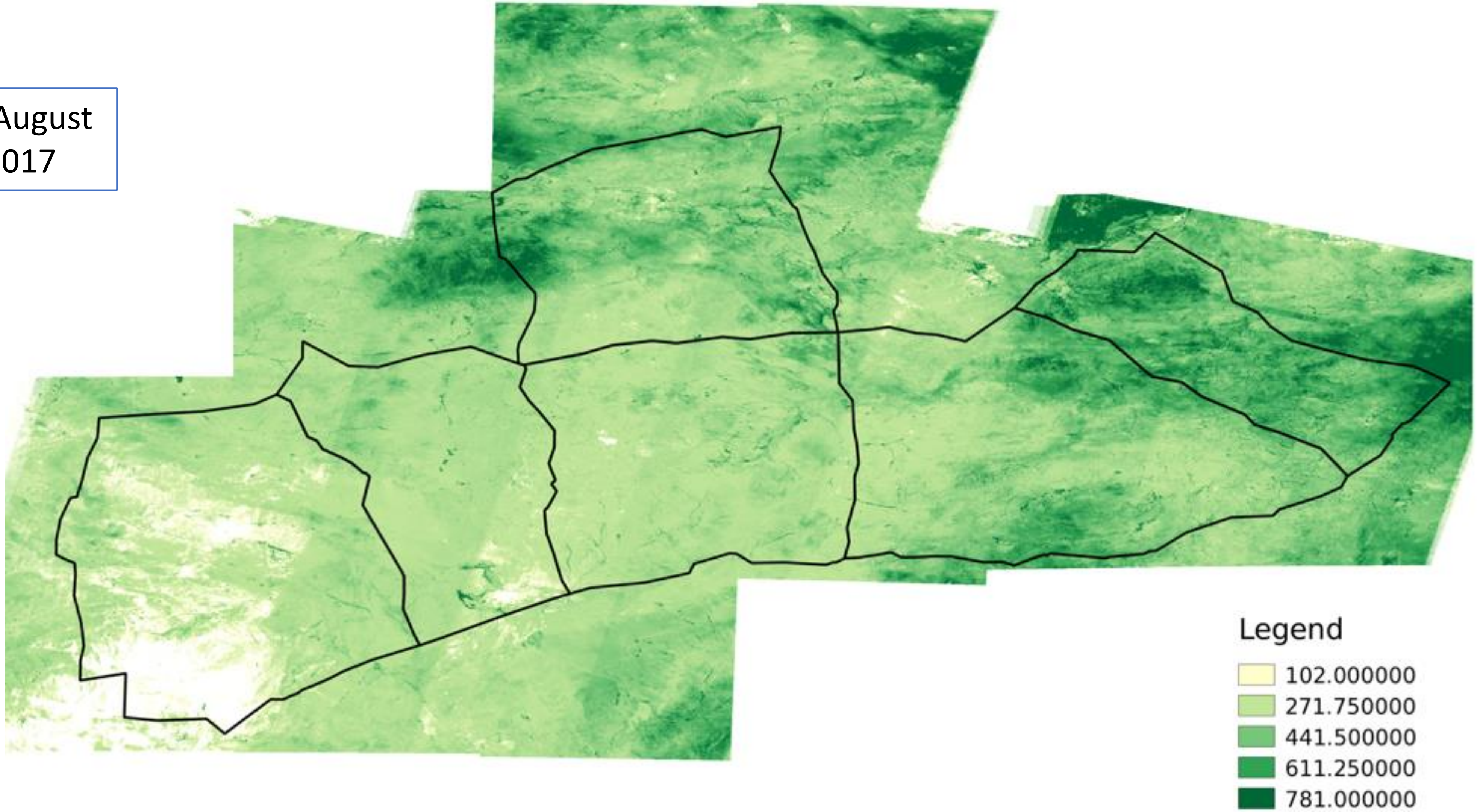
Vegetation cover:
NDVI in green in the background
Total vegetation cover from field observations in purple



SAVI August 14th 2016

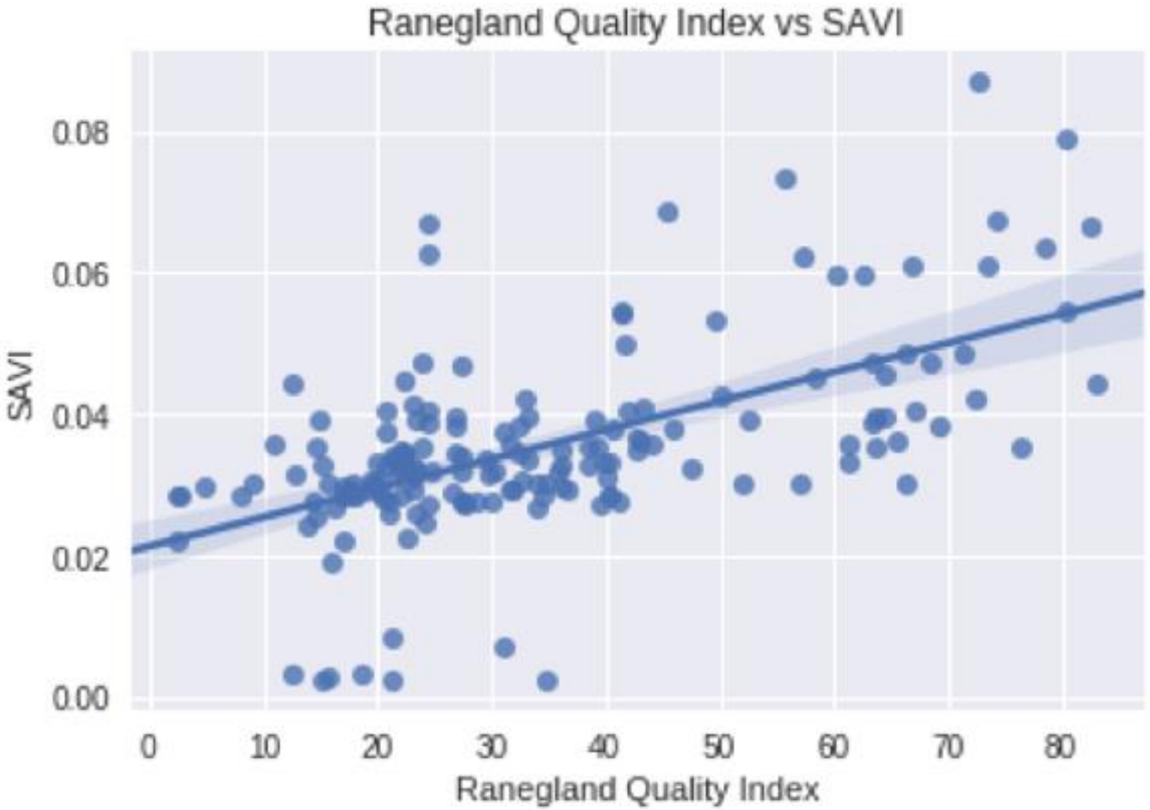


SAVI August 13th 2017



Short-term vegetation patterns: SAVI vs. Rangeland Metric

SAVI taken from Landsat during same windows as on-the-ground sampling




```
                            OLS Regression Results
==============================================================================
Dep. Variable:              Rangeland   R-squared:                       0.346
Model:                            OLS   Adj. R-squared:                  0.342
Method:                 Least Squares   F-statistic:                     88.46
Date:                Mon, 18 Jun 2018   Prob (F-statistic):           3.98e-17
Time:                        22:41:36   Log-Likelihood:                -701.77
No. Observations:                 169   AIC:                             1408.
Df Residuals:                     167   BIC:                             1414.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      4.7131      3.398      1.387      0.167      -1.995      11.421
ndvi         843.2234     89.652      9.406      0.000     666.227    1020.220
==============================================================================
Omnibus:                        5.875   Durbin-Watson:                   1.871
Prob(Omnibus):                  0.053   Jarque-Bera (JB):                6.019
```

NDVI August 14th 2016

NDVI August 13th 2017

```
                            OLS Regression Results
==============================================================================
Dep. Variable:              Rangeland   R-squared:                       0.362
Model:                            OLS   Adj. R-squared:                  0.358
Method:                 Least Squares   F-statistic:                     97.96
Date:                Fri, 15 Jun 2018   Prob (F-statistic):           1.39e-18
Time:                        18:19:08   Log-Likelihood:                -724.56
No. Observations:                 175   AIC:                             1453.
Df Residuals:                     173   BIC:                             1459.
Df Model:                           1
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
Intercept      5.5229      3.102      1.781      0.077      -0.599      11.645
ndvi         435.2948     43.982      9.897      0.000     348.485     522.104
==============================================================================
Omnibus:                        2.134   Durbin-Watson:                   1.799
Prob(Omnibus):                  0.344   Jarque-Bera (JB):                1.791
```